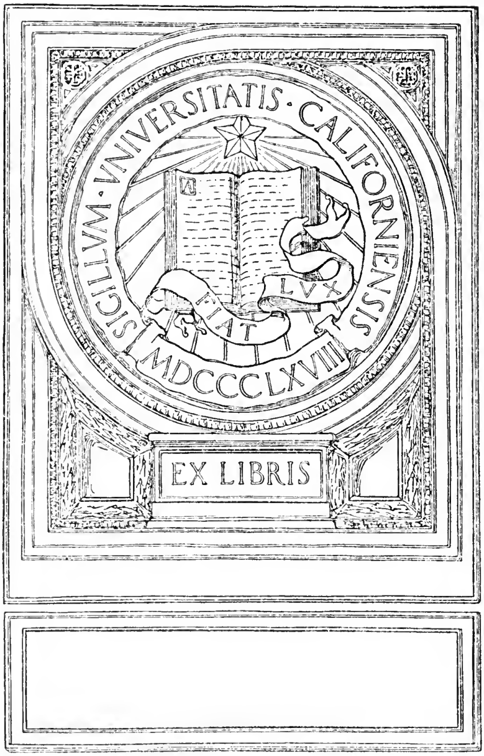
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HYDRAULIC TABLES

SHOWING THE LOSS OF HEAD DUE TO THE FRICTION OF WATER FLOWING IN PIPES, AQUEDUCTS, SEWERS, ETC.

AND

THE DISCHARGE OVER WEIRS

BY

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FIRST EDITION

FIRST THOUSAND

NEW YORK

JOHN WILEY & SONS

LONDON: CHAPMAN & HALL, LIMITED

1905

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$R = \frac{\text{area}}{\text{w.p.}}$ vel ... $= \frac{v^2}{2g}$ for

Entrance $= .5 \frac{v^2}{2g}$

CONTENTS.

INTRODUCTION.

THE following tables show the flow of water in pipes and other passages, as computed by the Hazen-Williams hydraulic slide-rule, based upon the formula

$$v = cr^{0.63}s^{0.54}0.001^{-0.04}.$$

The most commonly used formula for determining the velocity of flow of water in pipes and channels is the Chezy formula, namely,

$$v = c\sqrt{sr},$$

where v is the velocity in feet per second, s is the hydraulic slope, and r the hydraulic radius in feet. c is a factor the value of which is an approximation to a constant, but depends upon the roughness of the pipe and upon the hydraulic radius and slope. The variations in the value of c are considerable, and make the general use of the formula difficult.

Kutter's formula was devised to compute the value of c in the Chezy formula. The value of c so computed depends upon an assumed coefficient of roughness, upon the slope, and upon the hydraulic radius. With the same degree of roughness the value of c increases with the hydraulic slope and with the hydraulic radius. This is because the exponents used for these terms in the formula are below the true values. If the exponents were increased to correspond more nearly with the facts, the variations in the value of c would become less. If exponents could be selected agreeing perfectly with the facts, the value of c would depend upon the roughness only, and for any given degree of roughness c would then be a constant. It is not possible to reach this actually, because the values of the exponents vary with different surfaces, and also their values may not be exactly the same for large diameters and for small ones, nor for steep slopes and for flat ones. Exponents can be selected, however, representing approximately average conditions, so that the value of c for a given condition of surface will vary so little as to be practically constant. Several such "exponential" formulas have been suggested. These formulas are among the most satisfactory yet devised, but their use has been limited by the difficulty in making computations by them.

This difficulty was eliminated by the use of a slide-rule constructed for that purpose.

The exponents in the formula used were selected as representing as nearly as possible average conditions, as deduced from the best available records of experiments upon the flow of water in such pipes and channels as most frequently occur in water-works practice. The last term, $0.001^{-0.04}$, is a constant, and is introduced simply to equalize the value of c with the value in the Chezy formula, and other exponential formulas which may be used, at a slope of 0.001 instead of at a slope of 1.

The slide-rules were furnished by Mr. G. G. Ledder, 9 Province Court, Boston, Mass., the work being done in Germany. Suitable scales were laid out and the position of each graduation was computed to 0.01 millimeter. The drawings were then engraved upon steel and reproduced upon slide-rules of the general size and appearance of the ordinary 10-inch Mannheim rule. The graduation is very perfectly done, and the accuracy obtained is practically that which can be secured with the ordinary slide-rule of this size.

All the computations of figures contained in this volume, except a few fundamental ratios, have been made with the slide-rule, and only such accuracy has been sought as can readily be obtained by this method of computation.

This formula has been used by the authors for some time, and it is hoped that the tables will be useful to those not accustomed to the use of the slide-rule, and also to those who use the slide-rule, as a reference showing velocities and velocity heads, and establishing beyond question the position of the decimal point, which is the most troublesome feature in the use of the slide-rule to beginners.

These tables are not confined to a single value of the coefficient of roughness, which is called c. Instead, a series of values of c is given in the various columns, and under each are placed the corresponding losses of head. The headings also indicate in a general way the class of pipe for which the particular coefficient should be used, but these indications are only general, and it is the intention to leave the matter so that users can select such values of c as in their judgment represent the particular conditions upon which they are figuring.

The gradual roughening of the interior of cast-iron pipe is one of the most familiar of water-works phenomena. It is also one of the most difficult to compute. In a general way it may be said that in a series of years, which is not long compared with the total life of the pipe, the roughening of the surface and the reduction of the area through rusting and tuberculation reach such an extent that twice as much head is consumed in sending a given volume of water through it as was the case when the pipe was new.

In a particular set of foreign tables, based on the Darcy formula,

the loss of head is given for new pipe, and in the second column, designated old pipe, a figure twice as large is given. This has certain advantages over a table of factors to be applied to pipes of different ages, as has been done in several American publications, because it is less apt to be forgotten; and while it is a crude precedure, it keeps in mind the fact that old pipe will pass very much less water than new pipe.

In this volume effort has been made to put this subject in better shape. It is a difficult matter to handle adequately, for no two pieces of iron pipe deteriorate at the same rate, and any figures given are therefore at best only approximations to averages, which averages may be very far from individual cases.

The system used is to put certain figures surrounded by circles over the columns. This mark was adopted because no words could be found sufficiently concise and at the same time accurate. Over the column for $c=140$ are placed two zeros in a circle: 00. That indicates that this coefficient is obtained with the very best cast-iron pipe, laid perfectly straight, and when new. Over $c=130$ is placed one zero in a circle, 0, and this is the value that can be fairly counted on for good new cast-iron pipe. Over the following columns are placed figures in circles. These figures show the age in years at which, on an average, as nearly as we know, cast-iron pipe will reach the values given in the column underneath. It must be understood that these are necessarily very rough approximations, based on the best data available, which are principally for soft and clear but unfiltered river-waters. Hard waters and lake waters will often attack the pipe less rapidly, and the figures must then be increased. Sometimes they must be multiplied by two or more. Other waters will corrode the pipes more rapidly than the average, and for them the values will be reached more quickly than the figures indicate.

The divergence with different castings and with different kinds of water is greatest in the smallest pipes, and no attempt is made to extend the figures in the circles to the sizes below four inches in diameter.

Steel pipes tuberculate and corrode in much the same manner as cast-iron pipes. On account of the rivets and in-and-out joints the average value of c is lower than for cast-iron pipe. The data at hand indicate a value of 110 for new pipe, decreasing in the course of about ten years to 100. For older pipes, as far as the present data go, steel pipe of a given age will carry the same quantity of water as cast-iron pipe of the same size and ten years older.

On the Value of c.—In the *Engineering Record* of March 28, 1903, was published by the authors a table of the values of c computed from published experiments upon the friction of water in pipes and conduits of various kinds, the results being selected as the most reliable available data. This table, with some additions, is as follows:

TABLE NO. 1.—PIPE VALUES.

Experimenter.	Diameter in Inches.	Number of Observations.	Range of Velocity, Feet per Second.	Range of c in H. & W. Formula.	Mean Value of c.	Remarks.
			NEW CAST-IRON PIPE.			
Darcy	3.22	8	0.36 to 5.15	119.5 to 120.0	120	Uncoated
"	5.39	8	0.5 " 7.48	132.1 " 125.8	129	"
"	7.40	6	1.6 " 8.22	125.0 " 116.0	121	"
Williams, Hubbell, Fenkell	12	30	1.0 " 5.00	139.3 " 148.5	144	Coated, very straight, no specials
Iben	12	4	1.6 " 3.1	107.0 " 121.5	114	Coated, Bonn service main
"	12	4	1.6 " 3.1	106.0 " 117.0	111	" " " "
Williams, Hubbell, Fenkell	16.02	20	1.0 " 5.0	146.0 " 145.8	146	" well laid
" " "	16.02	30	1.0 " 5.0	145.0 " 145.6	145	" " "
Lampe	16.48	4	1.6 " 3.1	129.0 " 133.0	131	" Danzig main
Darcy	19.68	9	1.4 " 3.7	112.0 " 117.8	115	Uncoated
Williams, Hubbell, Fenkell	29.96	30	1.25 " 2.90	138 " 142	140	Coated, straight, no specials
Kuichling	36	2	4.2	129	......	" Rochester main
Stearns	48	3	2.6 to 6.2	142.0 to 141.0	142	" Rosemary siphon
Gale	48	1	3.5	112.3	......	" Edinburgh main
Fenkell	60	5	0.73 to 1.10	105.0 to 110.0	107	" Erie Intake 8 years old
			CLEANED CAST-IRON PIPE.			
Darcy	1.43	7	0.4 to 3.7	130 to 134	132	Paris main
"	3.16	7	0.6 " 5.0	124 " 114	119	" "
Brackett	6	6	0.95 " 2.46	100 " 86	93	Boston main
Darcy	9.63	7	0.9 " 8.44	110 " 103	107	Paris main
"	11.69	8	0.8 " 10.4	107 " 106	107	" "
FitzGerald	48	21	2.0 " 5.0	144 " 141	142	Rosemary siphon

Tuberculated Cast-iron Pipe.

Darcy	1.41	6	0.26 to 2.1	86 to 76	81	Paris main
"	3.13	6	0.4 " 3.7	82 " 85	83	" "
Brackett	4	4	0.47 " 1.23	13 " 20	16	Boston main
"	4	3	0.51 " 1.19	15 " 22	18	" "
"	6	7	0.38 " 1.70	38 " 30	34	" "
"	6	8	0.38 " 1.70	44 " 42	43	" "
Darcy	9.57	8	1.0 " 1.26	89 " 79	84	Paris main
Forbes	16	4	1.15 " 1.97	111 " 102	106	Brookline force main
Kuichling	36	2	4.08	81	......	Rochester main
FitzGerald	48	35	1.0 to 5.0	119 to 105	112	Rosemary siphon

Riveted Pipe.

Darcy	1.05	7	.30 to 2.79	131 to 125	128	Coated sheet iron
Giltner and Ketchum	3.00	222	.18 " 2.33	118 " 116	119	Galvanized sheet iron
Darcy	3.25	7	.58 " 6.14	124 " 143	133	Coated sheet iron
"	7.72	10	.59 " 10.01	141 " 144	142	" " "
H. Smith, Jr.	10.93	5	4.70 " 10.00	119 " 124	121	Riveted sheet iron
Darcy	11.22	7	1.30 " 10.52	123 " 136	129	Coated sheet iron
H. Smith, Jr.	12.67	4	4.60 " 10.10	121 " 118	119	Riveted sheet iron
" " "	14.76	6	4.40 " 12.10	132 " 123	127	" " "
Herschel	36.00	8	0.56 " 5.70	122 " 98	110	Riveted steel
Kuichling	38.00	10	3.71 " 3.91	107 " 110	108	Riveted sheet steel
Herschel	42.00	24	0.96 " 4.99	130 " 88	109	Riveted steel
"	47.4	51	2.04 " 6.06	126 " 91	104	" "
Marx, Wing and Hoskins	72.24	29	1.57 " 3.80	117 " 108	111	Riveted sheet steel
" " " "	72.24	39	1.12 " 4.80	87 " 100	97	" " "
Herschel	102.96	40	1.00 " 4.50	127 " 101	114	" " iron

Wooden-stave Pipe.

Adams	14.05	5	.70 to 1.53	124 to 134	129	Los Angeles
Noble	44	11	3.46 " 4.80	112 " 115	113	Seattle
"	54	11	2.28 " 4.70	119 " 127	123	"
Marx, Wing and Hoskins	72.36	48	1.20 " 5.30	124 " 117	120	Ogden

PIPE VALUES—(*Continued*).

Experimenter.	Diameter in Inches.	Number of Observations.	Range of Velocity, Feet per Second.	Range of c in H. & W. Formula.	Mean Value of c.	Remarks.
			RECTANGULAR UNPLANED WOODEN PIPES.			
Darcy and Bazin.	2.625′×1.64′ $r=.505$	8	1.67 to 6.37	122.0 to 112.0	115	Long dimension horizontal
" " "	1.575′×.984′ $r=.303$	8	1.23 " 5.31	116.8 " 106.8	114	" " "
			CEMENT PIPE.			
Fanning.	20	11	1.49 to 4.04	127 to 118	122	Cement-lined iron
Bazin.	31.50	10	2.78 " 6.60	148 " 144	146	Experimental conduit
			CIRCULAR BRICK TUNNELS.			
Clarke.	90	2	3.769 to 3.798	113 to 111	112	Boston main drainage sewer
Benzenberg.	144	10	3.90 " 7.00	95 " 80	87	Milwaukee sewer
			NEW WROUGHT-IRON PIPE.			
H. Smith, Jr.	0.628	2	1.03 to 1.58	100 to 127	113	½-inch gas-pipe
" " "	1.054	8	0.96 " 3.17	114 " 134	124	1- " "
			NEW GALVANIZED WROUGHT-IRON PIPE.			
Saph and Schoder.	1.042	7	2.80 to 10.04	99.0 to 108.0	105	No fittings. Standard 1″ pipe
" " "	0.850	14	2.62 " 11.47	121.0 " 128.0	126	" " " ¾″ "
" " "	0.626	7	2.46 " 12.78	117.5 " 121.0	119	" " " ½″ "
" " "	0.486	8	1.67 " 10.88	111.0 " 116.0	114	" " " ⅜″ "
" " "	0.350	9	1.86 " 10.76	88.0 " 98.5	92	" " " ¼″ "

			NEW BRASS PIPE.			
Saph and Schoder	0.50	39	0.95 to 14.97	129 to 146	131	Seamless drawn
" " "	0.63	20	0.65 " 6.76	142 " 149	145	" "
" " "	0.82	16	0.72 " 5.47	130 " 146	138	" "
" " "	1.05	10	0.36 " 3.09	131 " 145	138	" "
" " "	1.24	16	0.43 " 3.64	130 " 144	137	" "
" " "	1.50	16	0.38 " 4.36	130 " 147	138	" "
" " "	2.09	9	0.63 " 4.95	140 " 150	145	" "
			NEW LEAD PIPE.			
Reynolds	0.498	6	1.14 to 2.14	136 to 138	137	
Darcy	0.55	2	0.81 " 1.46	133 " 135	134	
"	1.06	5	0.62 " 3.35	122 " 139	130	
"	1.61	7	0.39 " 7.56	116 " 129	123	
			GLASS PIPE.			
H. Smith, Jr.	0.75	2	1.40 to 2.65	128 to 133	130	
" " "	0.92	2	1.95 " 2.94	131 " 135	133	
Darcy	1.95	5	0.50 " 6.92	119 " 125	122	
			NEW WOOD, BORED.			
H. Smith, Jr.	1.26	2	1.65 to 2.47	95 to 95	95	
			FIRE-HOSE.			
Freeman	2.65	4	12.50 to 20.00	144 to 141	143	"A," extremely smooth
"	2.47	3	13.40 " 20.00	140	140	"C," rubber-lined
"	2.49	4	13.20 " 21.00	139 to 136	138	"D," "
"	2.68	4	7.50 " 17.00	136 " 130	132	"E," "
"	2.69	4	11.50 " 18.00	114 " 119	116	"I," "
"	2.12	3	14.00 " 21.81	134 " 135	135	"M," "
"	2.53	8	3.50 " 19.00	122 " 101	106	"K," "mill hose"
"	2.60	7	3.50 " 20.00	93 " 87	89	"L," unlined linen hose

In a general way it may be said that for cast-iron pipe, very straight and smooth, c may be as high as 140, but for ordinary conditions 130 is a fair value for new pipe. As pipes rust and become dirty, the value of c decreases, as has been mentioned above. For new riveted steel pipe c is about 110.

In making estimates for pipe-lines where the carrying capacity after a series of years, rather than the value of the new pipe, is the controlling factor, a considerably lower value of c must be used, depending upon the amount of deterioration which is contemplated. A fair value for general computation is $c=100$ for cast-iron pipe and $c=95$ for steel pipe, but for small iron pipes a somewhat lower value of c should be taken. In the pipe tables the column of slopes for $c=100$ is printed in heavier-faced type than the rest, as these values are the ones which will probably be most often required. Lead, brass, tin, and glass, and other pipe presenting perfectly smooth surfaces, and perfectly straight, will give values of c up to 140. A very little falling off in the smoothness will reduce the value of c to 130 and 120, or even less. For smooth wooden pipe or wooden-stave pipe 120 seems a fair value. For masonry conduits of concrete or plastered, with very smooth surfaces, when clean, values of $c=140$ may be observed. Generally such surfaces become slime-covered, reducing the value of c to 130 or less in a moderate length of time; and if the surfaces are only a little less smooth, say in such shape as is represented by ordinary good work, the value of c is reduced to 120. A conservative value for general use with first-class masonry structures is about 120. For brick sewers much lower values may be used, and $c=100$ seems safe. For vitrified pipe $c=110$ may be used. It must be understood that these values depend entirely upon the smoothness and regularity of the surfaces, and are likely to vary in individual cases.

This formula was designed primarily for computing the flow of water in pipes. It seems reasonably well adapted for computing the flow in open channels, and the slide-rules have been made so as to allow this application. A table has been prepared to show the application of this formula to the most reliable experiments upon open channels. From the data therein presented the investigator may determine for himself the probable accuracy to be obtained and the value of c which should be used in a given case.

TABLE NO. 2.—OPEN-CHANNEL VALUES.

Experimenter.	Number of Observations.	Width at Surface, Feet.	Mean Depth at Deepest Part of Section, Feet.	Slope, Feet per 1000 Feet.	Range of r in Feet.	Range of v, Feet per Second.	Range of c in H. & W. Formula.	Remarks.
				RECTANGULAR CONDUITS.				
Darcy and Bazin, S. II	12	5.94	.18 to .91	4.9	.168 to .696	3.34 to 8.07	135 to 140	Surface of pure cement
" " " S. III	12	6.27	.20 " 1.04	4.9	.192 " .779	2.75 " 6.72	104 " 110	" " brick laid flat
" " " S. IV	11	6.01	.41 " 1.30	4.9	.357 " .910	2.95 " 5.57	76 " 78	" " gravel $\frac{3}{8}''$ to $\frac{7}{8}''$ diam.
" " " S. V	12	6.11	.32 " 1.46	4.9	.291 " .987	1.79 " 4.90	52 " 66	" " " $1\frac{1}{8}''$ to $1\frac{3}{8}''$ "
" " " S. VI	12	6.53	.26 " 1.28	2.08	.240 " .922	2.08 " 5.21	109 " 118	" " unplaned plank
" " " S. VII	12	6.53	.20 " .94	4.9	.188 " .727	2.71 " 7.15	112 " 118	" " " "
" " " S. VIII	12	6.53	.15 " .78	8.24	.147 " .630	3.52 " 8.57	113 " 118	" " " "
" " " S. IX	7	6.51	.30 " 1.44	1.5	.276 " .998	1.80 " 4.66	103 " 118	" " " "
" " " S. X	7	6.52	.18 " .87	5.9	.172 " .686	2.99 " 7.71	110 " 118	" " " "
" " " S. XI	7	6.50	.15 " .77	8.39	.146 " .621	3.54 " 8.74	117 " 119	" " " "
" " " S. XII	7	6.43	.33 " —*	1.5	.302 " 1.076	1.65 " 4.19	89 " 101	Surface covered with laths $\frac{3}{8}''$ deep×1.1″ wide, nailed $\frac{3}{8}''$ apart around sides and bottom transversely to current
" " " S. XIII	7	6.43	.22 " 1.05	5.9	.205 " .790	2.50 " 6.48	83 " 92	
" " " S. XIV	7	6.40	.19 " .94	8.86	.182 " .726	2.85 " 7.26	82 " 87	
" " " S. XV	7	6.43	.43 " 2.18	1.5	.378 " 1.299	1.28 " 3.11	60 " 67	Surface covered with lath as above but set 2″ apart
" " " S. XVI	7	6.44	.29 " 1.38	5.9	.264 " .965	1.91 " 4.91	54 " 61	
" " " S. XVII	7	6.40	.25 " 1.22	8.86	.232 " .885	2.21 " 5.57	54 " 58	
" " " S. XVIII	12	3.93	.27 " 1.46	4.9	.235 " .839	3.37 " 7.59	112 " 114	Surface of unplaned plank
" " " S. XIX	11	2.625	.26 " 1.50	4.3	.214 " .700	2.85 " 6.48	106 " 117	" " " "
" " " S. XX	9	1.575	.34 " .95	6.0	.237 " .431	3.57 " 5.49	106 " 111	" " " "

* Conditions of flow irregular.

OPEN-CHANNEL VALUES—(*Continued*).

Experimenter.	Number of Observations.	Width at Surface, Feet.	Mean Depth at Deepest Part of Section, Feet.	Slope, Feet per 1000 Feet.	Range of r in Feet.	Range of v, Feet per Second.	Range of c in H. & W. Formula.	Remarks.
TRAPEZOIDAL AND TRIANGULAR PLANK CONDUITS, UNPLANED.								
Darcy and Bazin, S. XXI	12	6.56	.40 to 1.77	1.5	.334 to 1.097	2.39 to 4.87	120 to 117	Sides at 45° for 1.64′, then vertical above; bottom 3.28′ wide
" " " S. XXII	12	variable	.30 " 1.44	4.9	.257 " .837	3.58 " 7.93	113 " 120	One side vertical, other at 45°; bottom 3.1′ wide
" " " S. XXIII	12	"	.92 " 2.37	4.9	.327 " .839	4.13 " 7.75	114 " 118	Both sides at 45°, vertex down.
SEMICIRCULAR CONDUITS.								
" " " S. XXIV	12	variable	.59 to 2.03	1.5	.366 to 1.034	3.02 to 6.11	145 to 152	Radius 2.05′, surface pure cement
" " " S. XXV	12	"	.61 " 2.09	1.5	.379 " 1.038	2.87 " 5.66	132 " 141	Radius 2.05′, surface cement mixed with $\frac{1}{3}$ of fine sand
" " " S. XXVI	13	"	.63 " 2.29	1.5	.390 " 1.148	2.61 " 5.54	121 " 129	Radius 2.295′, partly planed plank
" " " S. XXVII	10	"	variable	1.5	.454 " 1.012	2.17 " 3.95	90 " 99	Radius 2.00′, surface of small gravel $\frac{3}{8}''$ to $\frac{7}{8}''$ diameter set in cement
SMALL RECTANGULAR CONDUIT.								
" " " S. XXVIII	7	0.328	.036 to .215	4.7	.029 to .093	.90 to 2.16	115 to 132	Very smooth wood
" " " S. XXIX	5	0.328	.037 " .134	15.2	.030 " .074	1.87 " 3.56	124 " 133	" " "
" " " S. XXX	6	0.312	.048 " .269	8.1	.038 " .102	.72 " 1.88	57 " 82	Surface covered with cloth, lower corners rounded
" " " S. XXXI	9	0.312	.036 " .226	15.2	.031 " .095	.69 " 2.23	45 " 71	

OPEN-CHANNEL VALUES—(*Continued*).

Experimenter.	No. of Observations.	Mean Depth, Feet.	Slope, Feet per 1000 Ft.	Range of r in Feet.	Range of v, Feet per Second.	Range of c in H. & W. Formula.	Remarks.
				AQUEDUCTS.			
Fteley and Stearns.....	9	1.518 to 4.552	.1928 to .1922	1.078 to 2.333	1.827 to 2.926	135 to 132	Sudbury. Hard brick, fairly clean and smooth. Slope of bottom, 0.189. Horseshoe section, 8.3′ wide at bottom. Rad. = 4.5′. Invert 0.7′ deep
" " "	9	1.505 " 4.541	.1893 " .1889	1.071 " 2.330	1.844 " 2.937	137 " 134	
" " "	8	2.065 " 4.574	.0493 " .1860	1.400 " 2.338	1.432 " 2.909	141 " 134	
" " "	8	2.192 " 4.972	.0334 " .1793	1.468 " 2.417	1.207 " 2.889	140 " 135	
" " "	7	2.002 " 4.390	.1998 " .2600	1.366 " 2.294	2.161 " 3.386	134 " 131	
" " "	7	1.799 " 3.878	.2102 " .4913	1.251 " 2.151	2.448 " 4.407	140 " 132	
" " "	13	0.719 " 1.415	.014 " .1715	0.493 " 1.016	0.443 " 1.577	145 " 137	Same conduit carefully cleaned. Slope of bottom 0.16′
Fteley	17	....	0.133	0.76 " 3.84	1.11 " 3.4	118 " 130	New Croton, New York
"	......	12.8	0.133	3.93	3.07	122	Same conduit at point of maximum discharge
				BRICK SEWERS.			
Horton...............	5	1.02 to 2.89	0.500	0.688 to 1.539	1.99 to 3.44	116 to 121	Charlestown sewer 10 months in use
"	2	2.91 " 3.29	0.500	1.546 " 1.650	2.97 " 3.16	105 " 106	Do. 26 months in use
"	3	2.29 " 3.26	0.500	1.342 " 1.645	2.66 " 3.04	102 " 102	Do. 4 years in use
"	7	1.02 " 4.62	0.333	0.619 " 2.309	1.58 " 4.18	123 " 141	East Boston sewer 10 months in use
"	4	2.15 " 3.20	0.333	1.280 " 1.771	2.55 " 3.18	123 " 127	Do. 26 months in use
"	4	1.99 " 4.18	0.333	1.120 " 2.130	2.38 " 3.30	117 " 127	Do. 4 years in use
				CANALS AT MARSEILLES AND CRAPONNE.			
Darcy and Bazin, Baumgarten } S. I	1	2.5× 7.4*	3.72	1.504	10.26	123	Nearly rectangular; brick side and cement bottom
Ditto.	1	3.0× 8.5*	.84	1.774	5.55	134	Rectangular; smooth cut stone
Ditto.	1	1.2× 3.5*	29	.708	11.23	74	Nearly rectangular; hammered stone, rather rough
Ditto.	1	0.9× 3.5*	60	.615	13.93	65	
Ditto.	1	1.6× 3.9*	12.1	.881	7.58	67	
Ditto.	1	1.5× 3.6*	14	.835	8.36	71	
Ditto.	1	4.5×19.7*	.43	2.871	2.54	65	Mud, grass, and weeds; trapezoidal

* Surface width.

OPEN-CHANNEL VALUES—(*Continued*).

Experimenter.	Number of Observations.	Area in Square Feet.	Slope, Feet per 1000 Feet.	Range of r in Feet.	Range of v, Feet per Second.	Range of c in H. & W. Formula.	Remarks.
Cunningham (Ganges Canals, Roorkee Expts.)	5	....	.225 to .473	2.6 to 7.9	1.24 to 4.08	77 to 123	Solani Canal, Left. Masonry in good condition
Ditto.	4	....	.190 " .240	5.0 " 8.0	2.7 " 4.1	83 " 86	Solani Canal, Right. As last
Ditto.	8	....	.088 " .227	2.25 " 9.3	0.87 " 4.0	46 " 79	Solani Canal, Main. Sides masonry, bottom clay and irregular
Ditto.	2	....	.208 " .191	8 " 9	3.1 " 3.2	61.6 to 61.8	Betra. Similar to last
Ditto.	2	....	.140 " .160	6.3 " 7.5	2.6 " 2.9	74.4 " 69.2	Jasli. Similar
Ditto.	1	....	.231	8.6	4.0	72	15 mile, old side. Earth beds very rough
Ditto.	3	....	.291 to .306	4.1 to 4.8	2.7 to 2.9	66.5 to 66	Kamehera. Similar to last

MASONRY SLUICEWAYS.

Experimenter.	Number of Observations.	Area in Square Feet.	Slope, Feet per 1000 Feet.	Range of r in Feet.	Range of v, Feet per Second.	Range of c in H. & W. Formula.	Remarks.
Darcy and Bazin, S. XXXII	4	2.1 to 5.1	101.0	.324 to .662	12.29 to 21.09	65 to 72	Hammer-dressed, nearly rectangular. Bottom width 5.91′. Some adhering slime
" " " S. XXXIII	4	2.9 " 7.0	37.0	.424 " .852	9.04 " 15.08	70 " 75	
" " " S. XXXIV	5	8.9 " 27.5	14.6	.856 " 1.694	4.19 " 8.99	34 " 48	Flat trapezoid, hammer-dressed, covered with moss & mud. Bottom width 6.50′
" " " S. XXXV	5	6.6 " 21.6	14.2	.703 " 1.491	5.66 " 11.26	53 " 66	Same as last, but cleaned. Bottom width 5.87′

CANALS.

Darcy and Bazin, S. XXXIX	4	2.0 to 4.9	8.1	.406 to .766	5.73 to 8.75	104to110	Smooth masonry. Nearly rectangular. Bottom width 3.9′
" " " S. XL	4	10.5 " 24.6	.936 to .964	1.05 " 1.64	1.08 " 1.71	34 " 40	Trapezoidal rough stone. Little vegetation. Bottom width 4.2′
" " " S. XLII	4	10.5 " 23.1	.525 " .487	1.00 " 1.67	1.01 " 1.74	45 " 58	Trapezoidal with earth bottom and masonry sides. Bottom width 7.1′
" " " S. XLIV	4	9.7 " 21.1	.35 " .30	1.07 " 1.71	1.12 " 2.18	65 " 94	Masonry in bad order. Vertical sides and circular invert. Bottom width 6.6′
" " " S. XLV	4	8.2 " 18.6	.305 " .347	.98 " 1.60	1.32 " 2.47	80 "103	Similar to last, but in better order. Bottom width 6.2′
" " " S. XLVI	4	7.4 " 16.6	.648 " .683	.88 " 1.50	1.47 " 2.78	64 " 84	Similar. Bottom width 6.6′
" " " S. XLVII	4	11.8 " 26.8	.464 " .493	1.09 " 1.71	.82 " 1.68	37 " 55	Earth, some vegetation. Form nearly arc of circle
" " " S. XLVIII	4	10.1 " 25.9	.555 " .515	.99 " 1.71	.96 " 1.75	42 " 56	
" " " S. XLIX	4	10.9 " 30.8	.250 " .275	.96 " 1.78	.89 " 1.47	61 " 71	Earth, no vegetation. Trapezoidal. Bottom width 6.5′
" " " S. L	4	11.3 " 32.0	.310 " .330	1.05 " 1.85	.82 " 1.41	47 " 60	Similar to last. Bottom width 6.3′
" " " S. XXXVI	4	13.0 " 29.1	.678 " .622	1.14 " 1.74	.91 " 1.65	33 " 47	Trapezoidal in earth with vegetation. Bottom width 3.7′
" " " S. XXXVII	4	9.5 " 22.9	.792 " .858	.96 " 1.56	1.23 " 2.00	45 " 52	Trapezoidal in stony earth. Little vegetation. Bottom width 3.9′
" " " S. XXXVIII	4	9.3 " 22.2	.957 " .993	.96 " 1.54	1.24 " 1.96	42 " 50	Similar to last. Bottom width 4.1′
" " " S. XLI	4	11.3 " 27.2	.445 " .455	1.04 " 1.71	.96 " 1.51	46 " 56	Similar to last. Bottom width 4.4′
" " " S. XLIII	4	11.6 " 28.7	.420 " .470	1.06 " 1.76	.89 " 1.39	43 " 47	Similar to last with vegetation. Bottom width 4.3′

No tables to show the application of these results, that is to say, tables corresponding to the pipe tables, have been made for open channels. The variations in the conditions of depth, width, slope and character of bottom and sides are so enormously great that solution of each particular problem by the use of the slide-rule is the only practical way of handling the subject.

The slide-rule will also be found more closely applicable to actual conditions in pipes than any tables, because it gives at once values for conditions falling between the values which it is practicable to show in the tables, and its use is therefore to be recommended in all cases where close computations are desirable.

$$V = C\sqrt{RS}$$

$$h_f = \frac{f L v^2}{2g D}$$

$$Q = C L H^{3/2}$$

SMALL BRASS PIPES.

$c = 130.$

MAY ALSO BE USED FOR STRAIGHT LEAD, TIN, AND DRAWN-COPPER PIPES.

Diameter in Inches.	Gallons Daily for $v=1$ Ft. per Second.	Loss of Head in Feet per 1000 feet of length.					
		$v=0.5'$	$v=1.0'$	$v=2.0'$	$v=3.0'$	$v=4.0'$	$v=5.0'$
0.03	3.2	*1170*	*2350*	*4700*	*7050*	*9400*	*11700*
0.04	5.6	*660*	*1310*	*2620*	*3940*	*5250*	*6600*
0.05	8.8	*420*	*840*	*1680*	*2520*	*3370*	4350
0.06	12.7	*290*	*580*	*1170*	*1750*	*2340*	3520
0.07	17.3	*215*	*430*	*860*	*1290*	1930	2950
0.08	22.6	*164*	*330*	*660*	*990*	1650	2500
0.09	28.5	*130*	*260*	*520*	840	1440	2200
0.10	35.3	*105*	*210*	*420*	750	1270	1940
0.11	42.7	*87*	*174*	*350*	670	1140	1730
0.12	51	*73*	*146*	*293*	605	1030	1560
0.14	69	*54*	*108*	239	505	860	1310
0.16	90	*41*	*82*	202	430	740	1120
0.18	114	*32*	*65*	178	375	640	980
0.20	141	*26*	*52*	157	333	570	860
0.22	171	*21*	*43*	141	300	510	770
0.24	203	*18*	*36*	127	270	460	700
0.26	238	*15*	32	116	245	418	640
0.28	277	*13*	30	106	225	382	580
0.30	317	*12*	27	98	209	354	540
0.35	432	*9*	23	83	175	299	450
0.40	564	*7*	19	70	149	252	385
0.45	714	*5*	17	61	130	220	335
0.50	880	4.15	15	54	114	195	295
0.55	1,070	3.75	13.4	48	102	174	265
0.60	1,270	3.35	12.1	44	92	157	240
0.65	1,490	3.07	11.0	40	84	144	220
0.70	1,730	2.80	10.1	36	77	132	200
0.75	1,990	2.59	9.4	34	71	121	184
0.80	2,260	2.40	8.7	31	66	113	170
0.85	2,550	2.23	8.1	29	62	105	159
0.90	2,860	2.10	7.6	27	58	98	148
0.95	3,180	1.96	7.1	26	54	92	139
1.00	3,525	1.85	6.7	24	51	87	131
1.10	4,250	1.65	6.0	21	46	78	117
1.20	5,080	1.50	5.4	19	41	70	106

Note.—Figures in italics are below the critical velocity and are computed by the formula $v = 475sd^2\left(\frac{t+10}{60}\right)$. t (temperature) is taken as 50° F.

SMALL PIPE.

WROUGHT-IRON-PIPE SIZES.

Nominal Size, Inches.	Actual Diameter, Inches.	Discharge in Gallons.		Velocity, Feet per Second.	Loss of Head in Feet per 1000 feet of length.				
		Per Minute.	Per 24 Hours.		Very Smooth and Straight. $c=140$	Smooth New Iron. $c=120$	Ordinary Iron. $c=100$	Old Iron. $c=80$	Very Rough. $c=60$
1/8	0.270	0.2	288	1.12	33	44	**62**	94	158
		0.4	576	2.24	118	158	**220**	335	570
		0.6	864	3.36	250	335	**470**	710	1210
		0.8	1,152	4.48	430	570	**800**	1210	2050
		1.0	1,440	5.60	650	860	**1210**	1830	3100
1/4	0.364	0.5	720	1.54	42	56	**78**	118	200
		1.0	1,440	3.08	150	200	**280**	430	730
		1.5	2,160	4.62	320	425	**600**	910	1540
		2.0	2,880	6.16	550	730	**1030**	1550	2600
		2.5	3,600	7.70	830	1100	**1530**	2320	4000
3/8	0.494	1	1,440	1.67	34	46	**64**	97	165
		2	2,880	3.35	125	167	**233**	350	600
		3	4,320	5.02	260	350	**490**	740	1260
		4	5,760	6.70	450	600	**840**	1260	2150
		5	7,200	8.37	680	900	**1260**	1900	3250
1/2	0.623	1	1,440	1.05	11	15	**21**	31	53
		2	2,880	2.10	40	53	**74**	112	192
		3	4,320	3.16	85	113	**158**	240	410
		4	5,760	4.21	145	192	**270**	410	700
		5	7,200	5.26	220	290	**410**	620	1050
		6	8,640	6.31	310	410	**570**	870	1470
		7	10,080	7.37	410	540	**760**	1150	1950
		8	11,520	8.42	520	700	**980**	1480	2500
		9	12,960	9.47	650	860	**1210**	1830	3100
		10	14,400	10.52	790	1050	**1470**	2230	3800
3/4	0.824	2	2,880	1.20	10	14	**19**	29	49
		3	4,320	1.80	22	29	**41**	61	105
		4	5,760	2.41	37	50	**70**	105	180
		5	7,200	3.01	56	75	**105**	159	270
		6	8,640	3.61	79	105	**147**	224	380
		8	11,520	4.81	135	180	**250**	380	650
		10	14,400	6.02	205	271	**380**	580	980
		12	17,280	7.22	285	380	**530**	800	1370
		15	21,600	9.02	430	570	**800**	1220	2030
		20	28,800	12.03	730	970	**1360**	2060	3500

SMALL PIPE.

WROUGHT-IRON-PIPE SIZES.

Nominal Size, Inches.	Actual Diameter, Inches.	Discharge in Gallons. Per Minute.	Per 24 Hours.	Velocity, Feet per Second.	Loss of Head in Feet per 1000 feet of length. Very Smooth and Straight. $c=140$	Smooth New Iron. $c=120$	Ordinary Iron. $c=100$	Old Iron. $c=80$	Very Rough. $c=60$
1	1.048	3	4,320	1.12	6.8	9.0	**12.6**	19.0	32
		4	5,760	1.49	11.5	15.2	**21.4**	32.3	55
		5	7,200	1.86	17.5	23.2	**32.5**	49.1	84
		6	8,640	2.23	24.5	32.5	**45.5**	69	117
		8	11,520	2.98	42.0	55	**78**	117	200
		10	14,400	3.72	63	84	**117**	177	300
		12	17,280	4.46	88	117	**164**	250	420
		14	20,160	5.20	117	155	**220**	330	560
		16	23,040	5.95	150	200	**280**	420	720
		18	25,920	6.69	185	250	**350**	520	890
		20	28,800	7.44	226	301	**420**	640	1090
		25	36,000	9.30	340	455	**640**	960	1640
		30	43,200	11.15	480	640	**890**	1350	2300
		35	50,400	13.02	640	850	**1190**	1800	3080
		40	57,600	14.88	820	1090	**1520**	2300	3900
1¼	1.380	4	5,760	0.86	3.0	4.0	**5.7**	8.6	14.5
		5	7,200	1.07	4.5	6.0	**8.4**	12.7	21.8
		6	8,640	1.29	6.4	8.6	**12.0**	18.2	31
		7	10,080	1.50	8.5	11.4	**15.9**	24	41
		8	11,520	1.72	11.0	14.5	**20.3**	31	53
		10	14,400	2.14	16.5	21.8	**30.5**	46	79
		12	17,280	2.57	23.0	30.8	**43**	65	110
		14	20,160	3.00	30.8	41	**57**	87	148
		16	23,040	3.43	39.2	52	**73**	111	189
		18	25,920	3.86	49	65	**91**	137	235
		20	28,800	4.29	60	79	**111**	168	286
		25	36,000	5.36	89	119	**166**	251	430
		30	43,200	6.43	126	169	**235**	358	610
		35	50,400	7.51	168	223	**312**	470	800
		40	57,600	8.58	214	285	**400**	610	1030
		50	72,000	10.72	325	432	**600**	920	1560
		60	86,400	12.87	450	610	**850**	1290	2200
		70	100,800	15.01	610	810	**1130**	1700	2900
		80	115,200	17.16	780	1030	**1450**	2200	3700
		90	129,600	19.30	960	1280	**1800**	2700	4600

1½-INCH WROUGHT-IRON PIPE.

(Actual Diameter, 1.611.)

Discharge in Gallons.		Velocity, Feet per Second.	Loss of Head in Feet per 1000 feet of length.				
Per Minute.	Per 24 Hours.		Very Smooth and Straight. $c=140$	Smooth New Iron. $c=120$	Ordinary Iron. $c=100$	Old Iron. $c=80$	Very Rough. $c=60$
4	5,760	0.63	1.42	1.87	**2.62**	4.0	6.8
5	7,200	0.79	2.13	2.83	**3.98**	6.0	10.3
6	8,640	0.94	2.98	3.98	**5.6**	8.4	14.3
7	10,080	1.10	3.97	5.3	**7.4**	11.2	19.2
8	11,520	1.26	5.1	6.8	**9.5**	14.3	24.2
9	12,960	1.42	6.3	8.4	**11.8**	17.9	30.6
10	14,400	1.57	7.7	10.2	**14.3**	21.7	36.6
12	17,280	1.89	10.8	14.3	**20.1**	30.4	52
14	20,160	2.20	14.3	19.1	**26.8**	40.5	69
16	23,040	2.52	18.3	24.4	**34.1**	52	88
18	25,920	2.83	22.8	30.2	**42.4**	64	109
20	28,800	3.15	27.8	37	**52**	78	134
22	31,680	3.46	33.0	44	**62**	93	159
24	34,560	3.78	38.8	52	**73**	108	185
26	37,440	4.09	45.1	60	**84**	127	217
28	40,320	4.41	52	69	**97**	146	248
30	43,200	4.72	59	78	**110**	166	282
35	50,400	5.51	78	103	**147**	220	374
40	57,600	6.30	100	133	**188**	281	480
45	64,800	7.08	124	166	**232**	350	600
50	72,000	7.87	152	202	**284**	428	730
55	79,200	8.66	181	240	**340**	510	870
60	86,400	9.44	212	281	**396**	600	1020
65	93,600	10.23	246	328	**459**	700	1180
70	100,800	11.02	282	376	**530**	800	1360
75	108,000	11.80	321	427	**600**	900	1540
80	115,200	12.59	361	480	**680**	1020	1730
85	122,400	13.38	405	540	**750**	1140	1940
90	129,600	14.17	450	600	**840**	1260	2140
95	136,800	14.95	498	660	**930**	1400	2390
100	144,000	15.74	550	730	**1020**	1540	2620
110	158,400	17.31	650	870	**1220**	1840	3120
120	172,800	18.89	770	1020	**1430**	2170	3690
130	187,200	20.46	890	1180	**1660**	2500	4260
140	201,600	22.04	1020	1360	**1900**	2880	4890

2-INCH PIPE OR HOSE.

(Actual diameter, 2.00 ins.)

Discharge in Gallons.		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Per Minute.	Per 24 Hours.			Very Smooth and Straight Brass, Tin, etc. $c=140$	Ordinary Straight Brass, Tin, etc. $c=130$	Smooth New Iron. $c=120$	Ordinary Iron. $c=100$	Old Iron. $c=80$	Very Rough. $c=60$	Badly Tuberculated. $c=40$
6	8,640	0.61	0.01	1.0	1.2	1.4	**2.0**	2.9	5.0	10.7
8	11,520	0.82	0.01	1.8	2.0	2.4	**3.3**	5.0	8.6	18.2
10	14,400	1.02	0.02	2.7	3.1	3.6	**5.0**	7.6	12.9	27.4
12	17,280	1.23	0.02	3.8	4.3	5.0	**7.0**	10.7	18.1	38.5
14	20,160	1.43	0.03	5.0	5.8	6.7	**9.4**	14.2	24.1	51
16	23,040	1.63	0.04	6.4	7.4	8.6	**12.0**	18.2	30.9	66
18	25,920	1.84	0.05	8.0	9.2	10.7	**14.9**	22.7	38.6	82
20	28,800	2.04	0.06	9.8	11.2	12.9	**18.2**	27.5	46.8	99
25	36,000	2.55	0.10	14.8	16.9	19.6	**27.3**	41.6	71	150
30	43,200	3.06	0.15	20.7	23.8	27.3	**38.4**	58	99	210
35	50,400	3.57	0.20	27.5	31.5	36.6	**51**	78	132	280
40	57,600	4.08	0.26	35.1	40.2	46.8	**66**	99	168	359
45	64,800	4.60	0.33	43.8	50	58	**82**	123	210	446
50	72,000	5.11	0.40	53	61	71	**99**	150	257	540
55	79,200	5.62	0.49	64	73	84	**118**	179	305	640
60	86,400	6.13	0.58	74	86	99	**139**	210	359	760
65	93,600	6.64	0.68	86	99	115	**161**	244	416	880
70	100,800	7.15	0.79	99	114	132	**184**	280	477	1010
75	108,000	7.66	0.91	113	129	149	**209**	318	540	1150
80	115,200	8.17	1.04	127	146	169	**237**	358	610	1280
90	129,600	9.19	1.31	158	182	210	**294**	447	760	1610
100	144 000	10.21	1.62	192	220	256	**358**	540	920	1960
110	158,400	11.23	1.96	230	262	306	**429**	650	1110	2330
120	172,800	12.25	2.33	271	310	360	**500**	760	1300	2760
130	187,200	13.28	2.73	312	360	418	**580**	880	1510	3190
140	201,600	14.30	3.17	360	413	479	**670**	1020	1730	3670
150	216,000	15.32	3.64	407	465	540	**760**	1140	1950	4180
160	230,400	16.34	4.14	460	530	610	**860**	1290	2210	4690
170	244,800	17.36	4.67	520	590	690	**960**	1460	2480	5300
180	259,200	18.38	5.23	570	650	760	**1070**	1620	2730	5800
190	273,600	19.40	5.84	630	720	840	**1180**	1780	3030	6400
200	288,000	20.42	6.46	690	800	920	**1290**	1960	3330	7100
220	316,800	22.47	7.82	830	950	1110	**1540**	2340	3990	8400
240	345,600	24.51	9.31	980	1120	1300	**1820**	2760	4700	9900
260	374,400	26.55	10.90	1130	1290	1510	**2110**	3190	5400	11500

2½-INCH PIPE OR HOSE.

(Actual diameter, 2.50 ins.)

Discharge in Gallons.		Velocity in Feet per Second	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length						
Per Minute.	Per 24 Hours.			Very Smooth and Straight Brass, Tin, etc. $c=140$	Ordinary Straight Brass, Tin, etc. $c=130$	Smooth New Iron. $c=120$	Ordinary Iron. $c=100$	Old Iron. $c=80$	Very Rough. $c=60$	Badly Tuberculated. $C=40$
8	11,250	0.52	0.00	0.6	0.7	0.8	**1.1**	1.7	2.9	6.1
10	14,400	0.65	0.01	0.9	1.0	1.2	**1.7**	2.6	4.3	9.2
12	17,280	0.78	0.01	1.3	1.4	1.7	**2.4**	3.6	6.1	12.9
14	20,160	0.92	0.01	1.7	2.0	2.3	**3.2**	4.7	8.2	17.4
16	23,040	1.05	0.02	2.2	2.5	2.9	**4.1**	6.2	10.5	22.2
18	25,920	1.18	0.02	2.7	3.1	3.6	**5.0**	7.6	12.9	27.3
20	28,800	1.31	0.03	3.3	3.8	4.3	**6.1**	9.2	15.7	33.2
25	36,000	1.63	0.04	4.9	5.7	6.6	**9.2**	13.9	23.7	50
30	43,200	1.96	0.06	6.9	8.0	9.2	**12.9**	19.5	33.2	70
35	50,400	2.29	0.08	9.2	10.6	12.3	**17.2**	26.0	44.1	94
40	57,600	2.61	0.11	11.8	13.5	15.7	**22.0**	33.2	57	120
50	72,000	3.27	0.17	17.8	20.6	23.8	**33.2**	51	86	182
60	86,400	3.92	0.24	24.9	28.7	33.2	**46.5**	70	120	254
70	100,800	4.58	0.33	33.2	38.1	44.2	**62**	94	160	338
80	115,200	5.23	0.43	42.5	48.8	56	**79**	120	204	433
90	129,600	5.88	0.54	53	61	70	**98**	149	254	540
100	144,000	6.54	0.66	64	74	86	**120**	182	309	660
120	172,800	7.84	0.95	90	103	120	**168**	254	433	920
140	201,600	9.15	1.30	120	138	159	**223**	339	580	1220
160	230,400	10.46	1.70	156	178	207	**290**	440	750	1570
180	259,200	11.76	2.15	191	219	254	**357**	540	920	1940
200	288,000	13.07	2.66	232	267	309	**431**	660	1120	2370
220	316,800	14.38	3.22	277	318	369	**520**	780	1330	2820
240	345,600	15.69	3.82	330	376	438	**610**	920	1570	3340
260	374,400	16.99	4.48	378	432	500	**700**	1070	1810	3860
280	403,200	18.30	5.20	432	497	580	**810**	1220	2080	4400
300	432,000	19.61	5.98	493	570	660	**920**	1390	2370	5000
320	460,800	20.92	6.80	560	640	740	**1030**	1570	2670	5700
340	489,600	22.22	7.68	620	710	820	**1160**	1750	2980	6400
360	518,400	23.53	8.60	690	790	920	**1280**	1940	3310	7100
380	527,200	24.84	9.60	780	890	1020	**1420**	2160	3670	7800
400	576,000	26.14	10.62	840	960	1120	**1560**	2370	4020	8600
420	604,800	27.45	11.70	920	1050	1220	**1710**	2590	4400	9300
440	633,600	28.76	12.85	1000	1150	1330	**1860**	2810	4800	10200
460	662,400	30.07	14.00	1110	1260	1460	**2050**	3100	5300	11200

3-INCH PIPE.

(Actual diameter, 3.00 ins.)

Discharge in Gallons.		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Per Minute.	Per 24 Hours.			Very Smooth and Straight Brass, Tin, etc. $c=140$	Ordinary Straight Brass, Tin, etc. $c=130$	Smooth New Iron. $c=120$	Ordinary Iron. $c=100$	Old Iron. $c=80$	Very Rough. $c=60$	Badly Tuberculated. $c=40$
10	14,400	0.45	0.00	0.37	0.43	0.50	0.7	1.0	1.8	3.8
15	21,600	0.68	0.01	0.79	0.91	1.06	1.5	2.2	3.8	8.1
20	28,800	0.91	0.01	1.35	1.55	1.80	2.5	3.8	6.5	13.8
25	36,000	1.13	0.02	2.04	2.34	2.71	3.8	5.8	9.8	20.8
30	43,200	1.36	0.03	2.87	3.29	3.81	5.4	8.1	13.8	29.2
35	50,400	1.59	0.04	3.81	4.38	5.1	7.1	10.7	18.3	38.9
40	57,600	1.82	0.05	4.89	5.6	6.5	9.1	13.8	23.5	49.7
50	72,000	2.27	0.08	7.4	8.5	9.8	13.8	20.8	35.5	75
60	86,400	2.72	0.12	10.3	11.8	13.7	19.2	29.1	49.6	105
70	100,800	3.18	0.16	13.8	15.8	18.3	25.7	38.8	66	140
80	115,200	3.63	0.20	17.6	20.2	23.4	32.8	49.6	84	179
90	129,600	4.09	0.26	21.9	25.1	29.1	40.8	62	105	223
100	144,000	4.54	0.32	26.7	30.6	35.2	49.6	75	128	271
120	172,800	5.45	0.46	37.2	42.8	49.7	70	106	179	380
140	201,600	6.35	0.63	49.6	57	66	92	139	238	510
160	230,400	7.26	0.82	64	73	84	118	179	306	650
180	259,200	8.17	1.04	79	91	106	148	223	380	810
200	288,000	9.08	1.28	96	110	128	178	271	461	980
220	316,800	9.99	1.55	114	132	153	213	323	550	1170
240	345,600	10.89	1.84	134	154	179	251	380	650	1370
260	374,400	11.80	2.16	156	179	208	291	440	750	1590
280	403,200	12.71	2.51	179	206	238	334	510	860	1830
300	432,000	13.62	2.88	204	233	271	380	580	980	2080
320	460,800	14.52	3.28	229	263	306	428	650	1110	2330
340	489,600	15.43	3.71	257	294	342	479	720	1230	2610
360	518,400	16.34	4.15	286	328	380	530	800	1370	2910
380	527,200	17.25	4.62	317	361	420	590	890	1520	3210
400	576,000	18.16	5.11	348	399	461	650	980	1670	3520
420	604,800	19.06	5.64	380	436	510	710	1070	1830	3870
440	633,600	19.97	6.20	414	475	550	770	1170	1980	4220
460	662,400	20.88	6.78	449	520	600	840	1270	2160	4570
480	691,200	21.79	7.38	488	560	650	910	1370	2330	4980
500	720,000	22.70	8.00	530	600	700	980	1480	2520	5400
550	792,000	24.96	9.70	620	720	830	1170	1770	3010	6400
600	864,000	27.23	11.50	740	840	980	1370.	2070.	3520.	7400

4-INCH PIPE.

Discharge in Gallons.		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Per Minute.	Per 24 Hours.			00 $c=140$	0 $c=130$	4 $c=120$	13 $c=100$	26 $c=80$	45 $c=60$	75 $c=40$
20	28,800	0.51	0.00	0.33	0.38	0.44	**0.62**	0.9	1.6	3.4
25	36,000	0.64	0.01	0.50	0.58	0.67	**0.94**	1.4	2.4	5.1
30	43,200	0.77	0.01	0.70	0.81	0.94	**1.32**	2.0	3.4	7.2
35	50,400	0.89	0.01	0.94	1.07	1.24	**1.74**	2.6	4.5	9.6
40	57,600	1.02	0.02	1.20	1.38	1.59	**2.23**	3.4	5.8	12.2
50	72,000	1.28	0.03	1.82	2.08	2.41	**3.39**	5.1	8.8	18.5
60	86,400	1.53	0.04	2.53	2.91	3.38	**4.72**	7.2	12.2	25.9
70	100,800	1.79	0.05	3.38	3.88	4.50	**6.3**	9.5	16.3	34.4
80	115,200	2.04	0.06	4.32	4.97	5.8	**8.1**	12.2	20.8	44
90	129,600	2.30	0.08	5.4	6.2	7.2	**10.0**	15.2	25.9	55
100	144,000	2.55	0.10	6.5	7.5	8.8	**12.2**	18.5	31.3	66
120	172,800	3.06	0.15	9.2	10.5	12.2	**17.1**	25.8	44	93
140	201,600	3.57	0.20	12.2	14.0	16.2	**22.8**	34.4	59	124
160	230,400	4.08	0.26	15.7	17.9	20.8	**29.1**	44	75	159
180	259,200	4.60	0.33	19.4	22.2	25.9	**36.1**	55	93	198
200	288,000	5.11	0.41	23.7	27.0	31.2	**44**	66	113	240
220	316,800	5.62	0.49	28.1	32.2	37.3	**52**	79	135	287
240	345,600	6.13	0.58	33.0	37.9	44	**62**	93	158	337
260	374,400	6.64	0.69	38.3	44	51	**72**	108	184	391
280	403,200	7.15	0.79	44.0	50	59	**82**	124	210	448
300	432,000	7.66	0.91	50	57	67	**93**	141	240	510
320	460,800	8.17	1.04	56	65	75	**105**	158	271	580
340	489,600	8.68	1.17	63	72	84	**117**	178	303	640
360	518,400	9.19	1.31	70	80	93	**131**	197	337	710
400	576,000	10.21	1.62	85	98	113	**160**	241	410	870
450	648,000	11.49	2.05	107	122	141	**198**	299	510	1080
500	720,000	12.77	2.53	129	148	172	**240**	362	620	1320
550	792,000	14.04	3.06	153	177	205	**287**	433	740	1570
600	864,000	15.32	3.65	181	207	240	**337**	510	870	1840
650	936,000	16.59	4.28	209	240	279	**390**	590	1010	2130
700	1,008,000	17.87	4.96	240	276	320	**449**	680	1160	2450
750	1,080,000	19.15	5.70	272	312	362	**510**	770	1310	2790
800	1,152,000	20.42	6.48	308	352	410	**570**	870	1480	3120
850	1,224,000	21.70	7.30	343	395	458	**640**	970	1650	3510
900	1,296,000	22.98	8.20	382	439	510	**710**	1080	1840	3900

5-INCH PIPE.

Discharge in Gallons.		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Per Minute.	Per 24 Hours.			00 c=140	0 c=130	4 c=120	14 c=100	28 c=80	50 c=60	87 c=40
30	43,200	0.49	0.00	0.24	0.27	0.31	0.44	0.67	1.1	2.4
40	57,600	0.65	0.01	0.40	0.46	0.54	0.75	1.14	1.9	4.1
50	72,000	0.82	0.01	0.61	0.70	0.81	1.13	1.72	2.9	6.2
60	86,400	0.98	0.02	0.86	0.98	1.13	1.59	2.41	4.1	8.7
70	100,800	1.14	0.02	1.14	1.31	1.52	2.12	3.21	5.5	11.7
80	115,200	1.31	0.03	1.46	1.67	1.94	2.71	4.11	7.0	14.8
90	129,600	1.47	0.03	1.82	2.08	2.41	3.39	5.1	8.7	18.5
100	144,000	1.63	0.04	2.21	2.53	2.94	4.11	6.2	10.7	22.5
120	172,800	1.96	0.06	3.09	3.54	4.11	5.8	8.7	14.8	31.5
140	201,600	2.29	0.08	4.11	4.71	5.5	7.6	11.6	19.8	41.9
160	230,400	2.61	0.11	5.3	6.0	7.0	9.8	14.8	25.2	54
180	259,200	2.94	0.13	6.6	7.5	8.7	12.2	18.4	31.4	67
200	288,000	3.27	0.17	8.0	9.1	10.6	14.8	22.4	38.1	81
220	316,800	3.59	0.20	9.5	10.8	12.6	17.7	26.8	45.6	96
240	345,600	3.92	0.24	11.2	12.8	14.8	20.8	31.4	54	113
260	374,400	4.25	0.28	12.9	14.8	17.2	24.1	36.7	62	132
280	403,200	4.58	0.33	14.8	17.0	19.7	27.7	41.9	72	152
300	432,000	4.90	0.37	16.8	19.4	22.5	31.4	47.7	81	172
320	460,800	5.23	0.42	19.0	21.8	25.2	35.4	54	91	193
350	504,000	5.72	0.51	22.4	25.8	29.9	41.9	63	108	229
400	576,000	6.54	0.66	28.8	32.9	38.1	54	81	138	292
450	648,000	7.35	0.84	35.8	41.0	47.5	67	101	172	364
500	720,000	8.17	1.04	43.5	49.9	58	81	122	209	442
550	792,000	8.99	1.26	52	60	69	96	146	249	530
600	864,000	9.80	1.49	61	70	81	113	172	292	620
650	936,000	10.62	1.75	71	81	94	132	199	339	720
700	1,008,000	11.44	2.03	81	93	108	151	229	388	820
750	1,080,000	12.26	2.34	92	106	123	172	260	442	940
800	1,152,000	13.07	2.66	104	119	138	194	292	499	1060
850	1,224,000	13.89	2.99	117	133	154	217	328	560	1180
900	1,296,000	14.71	3.36	129	148	172	240	362	620	1320
950	1,368,000	15.52	3.74	143	163	190	267	402	690	1450
1000	1,440,000	16.34	4.15	157	180	209	292	443	750	1600
1100	1,584,000	17.97	5.00	187	214	249	349	530	900	1910
1200	1,728,000	19.61	5.96	220	251	292	409	620	1480	2240

6-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 $c=140$	0 $c=130$	4 $c=120$	15 $c=100$	30 $c=80$	55 $c=60$	95 $c=40$
50,000	0.0774	0.39	0.00	0.13	0.15	0.17	**0.24**	0.36	0.61	1.3
60,000	0.0928	0.47	0.00	0.18	0.20	0.24	**0.33**	0.51	0.86	1.8
70,000	0.1083	0.55	0.00	0.24	0.27	0.32	**0.44**	0.67	1.15	2.4
80,000	0.1238	0.63	0.01	0.30	0.35	0.41	**0.57**	0.86	1.46	3.1
90,000	0.1392	0.71	0.01	0.38	0.43	0.51	**0.71**	1.07	1.83	3.9
100,000	0.1547	0.79	0.01	0.46	0.53	0.61	**0.86**	1.30	2.22	4.7
110,000	0.1702	0.87	0.01	0.55	0.63	0.73	**1.03**	1.55	2.65	5.6
120,000	0.1857	0.95	0.01	0.65	0.74	0.86	**1.21**	1.84	3.11	6.6
140,000	0.2166	1.10	0.02	0.87	0.99	1.15	**1.62**	2.45	4.17	8.8
160,000	0.2476	1.26	0.02	1.10	1.26	1.46	**2.06**	3.10	5.3	11.2
180,000	0.2785	1.42	0.03	1.37	1.57	1.83	**2.56**	3.88	6.6	14.0
200,000	0.3094	1.58	0.04	1.67	1.91	2.22	**3.10**	4.70	8.0	17.0
220,000	0.3404	1.73	0.05	1.99	2.29	2.65	**3.71**	5.6	9.6	20.2
240,000	0.3713	1.89	0.06	2.33	2.69	3.11	**4.35**	6.6	11.2	23.9
260,000	0.4023	2.05	0.07	2.71	3.10	3.60	**5.0**	7.6	13.0	27.5
280,000	0.4332	2.21	0.08	3.11	3.58	4.14	**5.8**	8.8	15.0	31.7
300,000	0.4642	2.36	0.09	3.54	4.06	4.70	**6.6**	10.0	17.0	36.0
350,000	0.541	2.76	0.12	4.70	5.4	6.3	**8.8**	13.3	22.5	48.0
400,000	0.619	3.15	0.15	6.0	6.9	8.0	**11.3**	17.0	29.0	62
450,000	0.696	3.55	0.19	7.5	8.6	10.0	**14.0**	21.2	36.0	76
500,000	0.774	3.94	0.24	9.1	10.4	12.1	**16.9**	25.6	43.8	92
550,000	0.851	4.33	0.29	10.8	12.4	14.4	**20.1**	30.5	52	110
600,000	0.928	4.73	0.35	12.8	14.6	17.0	**23.8**	36.0	61	130
650,000	1.006	5.12	0.41	14.7	16.9	19.6	**27.5**	41.6	71	150
700,000	1.083	5.52	0.47	17.0	19.5	22.6	**31.6**	48.0	82	173
800,000	1.238	6.30	0.62	21.6	24.9	28.9	**40.4**	61	104	221
900,000	1.392	7.09	0.78	26.9	30.9	35.8	**50**	76	129	274
1,000,000	1.547	7.88	0.97	32.9	37.8	43.8	**61**	93	158	334
1,100,000	1.702	8.67	1.17	39.2	45.1	52	**73**	111	189	400
1,200,000	1.857	9.46	1.39	46.0	53	61	**86**	130	220	470
1,400,000	2.166	11.03	1.89	61	70	82	**114**	173	295	620
1,600,000	2.476	12.61	2.46	78	90	104	**146**	221	377	800
1,800,000	2.785	14.18	3.12	98	112	130	**182**	275	470	990
2,000,000	3.094	15.76	3.85	119	137	159	**222**	337	570	1210
2,200,000	3.404	17.34	4.65	141	162	188	**263**	400	680	1440

;minute
47.3
:86.

8-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 c=140	0 c=130	5 c=120	10 c=110	16 c=100	33 c=80	62 c=60
200,000	0.3094	0.89	0.01	0.41	0.47	0.55	0.64	0.77	1.16	1.98
220,000	0.3404	0.98	0.01	0.49	0.56	0.65	0.77	0.92	1.38	2.35
240,000	0.3713	1.06	0.02	0.58	0.66	0.77	0.90	1.07	1.62	2.78
260,000	0.4023	1.15	0.02	0.67	0.77	0.89	1.05	1.25	1.89	3.21
280,000	0.4332	1.24	0.02	0.77	0.88	1.02	1.20	1.43	2.16	3.69
300,000	0.4642	1.33	0.03	0.87	1.00	1.16	1.36	1.62	2.46	4.19
320,000	0.4951	1.42	0.03	0.98	1.13	1.31	1.54	1.84	2.78	4.72
340,000	0.526	1.51	0.04	1.10	1.26	1.46	1.72	2.05	3.10	5.3
360,000	0.557	1.60	0.04	1.22	1.40	1.62	1.91	2.28	3.44	5.9
380,000	0.588	1.68	0.04	1.35	1.55	1.80	2.11	2.51	3.80	6.5
400,000	0.619	1.77	0.05	1.48	1.70	1.97	2.32	2.76	4.20	7.1
450,000	0.696	1.99	0.06	1.85	2.11	2.45	2.89	3.43	5.2	8.9
500,000	0.774	2.22	0.08	2.25	2.58	2.99	3.50	4.18	6.3	10.7
550,000	0.851	2.44	0.09	2.68	3.07	3.55	4.19	5.0	7.6	12.9
600,000	0.928	2.66	0.11	3.14	3.61	4.19	4.91	5.9	8.9	15.1
650,000	1.006	2.88	0.13	3.64	4.18	4.84	5.7	6.8	10.3	17.5
700,000	1.083	3.10	0.15	4.19	4.80	5.6	6.5	7.8	11.8	20.0
750,000	1.160	3.32	0.17	4.73	5.4	6.3	7.4	8.8	13.3	22.8
800,000	1.238	3.55	0.20	5.3	6.1	7.1	8.4	9.9	15.1	25.7
900,000	1.392	3.99	0.25	6.7	7.6	8.9	10.4	12.4	18.8	32.0
1,000,000	1.547	4.43	0.30	8.1	9.3	10.8	12.7	15.1	23.0	39.0
1,100,000	1.702	4.88	0.37	9.6	11.1	12.8	15.1	18.0	27.2	46.2
1,200,000	1.857	5.37	0.44	11.3	13.0	15.1	17.7	21.1	32.0	54
1,300,000	2.011	5.76	0.52	13.1	15.1	17.5	20.5	24.5	37.0	63
1,400,000	2.166	6.20	0.60	15.1	17.3	20.0	23.5	28.1	42.5	72
1,500,000	2.321	6.65	0.69	17.0	19.5	22.6	26.7	31.8	48	82
1,600,000	2.476	7.09	0.78	19.2	22.0	25.5	30.0	35.8	54	93
1,800,000	2.785	7.98	0.99	23.8	27.2	31.6	37.1	41.2	67	114
2,000,000	3.094	8.86	1.22	29.0	33.3	38.7	45.4	54	82	140
2,200,000	3.404	9.75	1.47	34.9	40.0	46.2	54	65	98	167
2,400,000	3.713	10.64	1.76	41.0	47	55	64	77	116	198
2,600,000	4.023	11.52	2.06	47.5	55	63	74	89	134	229
2,800,000	4.332	12.41	2.39	55	62	73	85	102	153	261
3,000,000	4.642	13.30	2.74	62	71	83	97	116	175	300
3,200,000	4.951	14.18	3.12	70	80	93	109	130	197	336

10-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 c=140	0 c=130	5 c=120	10 c=110	17 c=100	35 c=80	68 c=60
300,000	0.464	0.85	0.01	0.29	0.34	0.39	0.46	**0.55**	0.83	1.41
320,000	0.495	0.91	0.01	0.33	0.38	0.44	0.52	**0.62**	0.93	1.59
340,000	0.526	0.96	0.01	0.37	0.42	0.49	0.58	**0.69**	1.04	1.78
360,000	0.557	1.02	0.02	0.41	0.47	0.55	0.64	**0.77**	1.16	1.98
380,000	0.588	1.08	0.02	0.45	0.52	0.60	0.71	**0.85**	1.28	2.19
400,000	0.619	1.13	0.02	0.50	0.57	0.66	0.78	**0.93**	1.40	2.40
450,000	0.696	1.28	0.03	0.62	0.71	0.83	0.97	**1.16**	1.75	3.00
500,000	0.774	1.42	0.03	0.76	0.87	1.01	1.18	**1.41**	2.13	3.63
550,000	0.851	1.56	0.04	0.90	1.03	1.20	1.41	**1.68**	2.55	4.34
600,000	0.928	1.70	0.04	1.06	1.21	1.41	1.65	**1.97**	3.00	5.1
650,000	1.006	1.84	0.05	1.23	1.41	1.64	1.92	**2.29**	3.46	5.9
700,000	1.083	1.99	0.06	1.41	1.62	1.88	2.21	**2.64**	4.00	6.8
750,000	1.160	2.13	0.07	1.60	1.84	2.14	2.50	**3.00**	4.52	7.7
800,000	1.238	2.27	0.08	1.81	2.08	2.41	2.83	**3.38**	5.1	8.7
900,000	1.392	2.55	0.10	2.24	2.58	3.00	3.50	**4.18**	6.3	10.8
1,000,000	1.547	2.84	0.12	2.73	3.13	3.63	4.27	**5.1**	7.7	13.1
1,100,000	1.702	3.12	0.15	3.25	3.72	4.32	5.1	**6.1**	9.2	15.5
1,200,000	1.857	3.40	0.18	3.82	4.40	5.1	6.0	**7.1**	10.8	18.4
1,300,000	2.011	3.69	0.21	4.44	5.1	5.9	6.9	**8.3**	12.5	21.4
1,400,000	2.166	3.97	0.24	5.1	5.8	6.8	8.0	**9.5**	14.4	24.5
1,500,000	2.321	4.26	0.28	5.8	6.7	7.7	9.0	**10.8**	16.3	27.9
1,600,000	2.476	4.54	0.32	6.5	7.5	8.7	10.2	**12.2**	18.5	31.4
1,800,000	2.785	5.11	0.41	8.1	9.3	10.8	12.7	**15.1**	22.9	39.0
2,000,000	3.094	5.67	0.50	9.9	11.3	13.1	15.4	**18.4**	27.8	47.2
2,200,000	3.404	6.24	0.60	11.7	13.4	15.6	18.3	**21.8**	33.0	56
2,400,000	3.713	6.81	0.72	13.7	15.7	18.3	21.4	**25.5**	38.7	66
2,600,000	4.023	7.38	0.84	16.0	18.4	21.3	25.0	**29.9**	45.0	77
2,800,000	4.332	7.94	0.98	18.3	21.0	24.3	28.6	**34.0**	51	88
3,000,000	4.642	8.51	1.12	20.8	23.8	27.6	32.5	**38.6**	59	100
3,200,000	4.951	9.08	1.28	23.5	27.0	31.2	36.8	**43.8**	66	113
3,400,000	5.26	9.65	1.44	26.3	30.2	35.0	41.2	**49**	74	127
3,600,000	5.57	10.21	1.62	29.2	33.5	38.9	45.5	**54**	82	140
3,800,000	5.88	10.78	1.80	32.5	37.2	43.1	51	**60**	92	156
4,000,000	6.19	11.35	2.00	35.5	40.8	47.3	56	**66**	100	171
4,500,000	6.96	12.77	2.52	44.3	51	59	69	**83**	125	213

12-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 c=140	0 c=130	5 c=120	10 c=110	17 c=100	26 c=90	37 c=80
100,000	0.155	0.20	0.00	0.02	0.02	0.02	0.02	0.03	0.04	0.04
200,000	0.309	0.39	0.00	0.06	0.07	0.08	0.09	0.11	0.13	0.16
300,000	0.464	0.59	0.01	0.12	0.14	0.16	0.19	0.22	0.27	0.34
400,000	0.619	0.79	0.01	0.20	0.24	0.27	0.32	0.38	0.47	0.58
500,000	0.774	0.99	0.02	0.31	0.36	0.41	0.48	0.58	0.71	0.88
600,000	0.928	1.18	0.02	0.44	0.50	0.58	0.68	0.81	0.99	1.23
700,000	1.083	1.38	0.03	0.58	0.66	0.77	0.91	1.08	1.32	1.64
800,000	1.238	1.58	0.04	0.74	0.85	0.99	1.15	1.38	1.68	2.09
900,000	1.392	1.77	0.05	0.92	1.06	1.23	1.45	1.72	2.10	2.61
1,000,000	1.547	1.97	0.06	1.12	1.29	1.50	1.76	2.10	2.57	3.18
1,100,000	1.702	2.17	0.07	1.34	1.54	1.79	2.10	2.50	3.04	3.79
1,200,000	1.857	2.36	0.09	1.58	1.81	2.10	2.47	2.94	3.58	4.45
1,300,000	2.011	2.56	0.10	1.83	2.10	2.43	2.85	3.40	4.14	5.2
1 400,000	2.166	2.76	0.12	2.10	2.40	2.79	3.26	3.90	4.76	5.9
1,500,000	2.321	2.96	0.14	2.39	2.73	3.17	3.71	4.43	5.4	6.7
1,600,000	2.476	3.15	0.15	2.69	3.09	3.58	4.20	5.0	6.1	7.6
1,700,000	2.630	3.35	0.17	3.00	3.45	4.00	4.69	5.6	6.8	8.5
1,800,000	2.785	3.55	0.20	3.33	3.82	4.43	5.2	6.2	7.6	9.4
1,900,000	2.940	3.74	0.22	3.70	4.24	4.92	5.8	6.9	8.4	10.4
2,000,000	3.094	3.94	0.24	4.06	4.65	5.4	6.4	7.6	9.2	11.5
2,200,000	3.404	4.33	0.29	4.85	5.6	6.5	7.6	9.0	10.9	13.7
2,400,000	3.713	4.73	0.35	5.7	6.5	7.6	8.9	10.5	12.8	16.0
2,600,000	4.023	5.12	0.41	6.6	7.6	8.8	10.3	12.3	15.0	18.6
2,800,000	4.332	5.52	0.47	7.6	8.7	10.1	11.9	14.1	17.2	21.5
3,000,000	4.642	5.91	0.54	8.6	9.9	11.5	13.5	16.0	19.4	24.3
3,500,000	5.41	6.89	0.74	11.4	13.2	15.3	17.9	21.3	26.0	32.3
4,000,000	6.19	7.88	0.96	14.5	16.6	19.3	22.6	27.0	33.2	41.0
4,500,000	6.96	8.87	1.22	18.0	20.6	24.0	28.2	33.6	41.2	51
5,000,000	7.74	9.85	1.50	22.0	25.1	29.2	34.3	41.0	50.0	62
5,500,000	8.51	10.84	1.82	26.5	30.3	35.1	41.4	49.4	60	75
6,000,000	9.28	11.82	2.17	31.1	35.7	41.4	48.8	58	70	88
7,000,000	10.83	13.79	2.96	41.2	47.2	55	65	77	94	116
8,000,000	12.38	15.76	3.86	53	61	71	83	99	121	150
9,000,000	13.92	17.73	4.89	66	75	87	103	122	148	185
10,000,000	15.47	19.70	6.03	81	93	107	126	150	183	228

16-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 c=140	0 c=130	5 c=120	11 c=110	18 c=100	27 c=90	39 c=80
200,000	0.309	0.22	0.00	0.014	0.016	0.019	0.022	**0.026**	0.03	0.04
400,000	0.619	0.44	0.00	0.051	0.058	0.068	0.080	**0.095**	0.12	0.14
600,000	0.928	0.66	0.01	0.108	0.124	0.143	0.169	**0.201**	0.24	0.30
800,000	1.238	0.89	0.01	0.183	0.210	0.242	0.287	**0.340**	0.41	0.52
1,000,000	1.547	1.11	0.02	0.278	0.319	0.369	0.434	**0.52**	0.63	0.78
1,200,000	1.857	1.33	0.03	0.389	0.446	0.52	0.61	**0.72**	0.88	1.09
1,400,000	2.166	1.55	0.04	0.52	0.60	0.69	0.81	**0.96**	1.18	1.47
1,600,000	2.476	1.77	0.05	0.66	0.76	0.88	1.03	**1.23**	1.50	1.87
1,800,000	2.785	1.99	0.06	0.82	0.95	1.09	1.28	**1.53**	1.87	2.32
2,000,000	3.094	2.22	0.08	1.00	1.15	1.33	1.57	**1.87**	2.28	2.82
2,200,000	3.404	2.44	0.09	1.19	1.37	1.59	1.87	**2.22**	2.71	3.35
2,400,000	3.713	2.66	0.11	1.41	1.62	1.87	2.19	**2.62**	3.19	3.98
2,600,000	4.023	2.88	0.13	1.63	1.87	2.17	2.55	**3.03**	3.69	4.60
2,800,000	4.332	3.10	0.15	1.87	2.15	2.49	2.92	**3.49**	4.24	5.3
3,000,000	4.642	3.32	0.17	2.12	2.43	2.83	3.32	**3.98**	4.81	6.0
3,200,000	4.951	3.55	0.19	2.39	2.75	3.19	3.75	**4.46**	5.4	6.8
3,400,000	5.26	3.77	0.22	2.69	3.08	3.57	4.19	**4.99**	6.1	7.6
3,600,000	5.57	3.99	0.25	2.98	3.42	3.97	4.65	**5.6**	6.8	8.4
3,800,000	5.88	4.21	0.28	3.29	3.78	4.38	5.1	**6.2**	7.4	9.3
4,000,000	6.19	4.43	0.31	3.61	4.15	4.80	5.6	**6.8**	8.2	10.2
4,500,000	6.96	4.99	0.39	4.50	5.2	6.0	7.0	**8.4**	10.2	12.7
5,000,000	7.74	5.54	0.48	5.5	6.3	7.3	8.6	**10.2**	12.4	15.4
5,500,000	8.51	6.09	0.58	6.6	7.5	8.7	10.2	**12.2**	14.8	18.4
6,000,000	9.28	6.65	0.69	7.7	8.8	10.2	12.0	**14.3**	17.4	21.7
6,500,000	10.06	7.20	0.81	8.9	10.2	11.8	13.9	**16.6**	20.2	25.1
7,000,000	10.83	7.76	0.93	10.2	11.7	13.6	15.9	**19.0**	23.2	28.8
7,500,000	11.60	8.31	1.08	11.6	13.3	15.4	18.1	**21.7**	26.2	32.8
8,000,000	12.38	8.86	1.22	13.1	14.9	17.4	20.3	**24.2**	29.6	36.9
9,000,000	13.92	9.97	1.54	16.3	18.6	21.7	25.2	**30.2**	36.9	45.9
10,000,000	15.47	11.08	1.90	19.8	22.6	26.2	30.9	**36.8**	45.0	56
11,000,000	17.02	12.19	2.30	23.6	27.0	31.2	36.9	**44.0**	54	66
12,000,000	18.57	13.30	2.74	27.8	31.8	36.9	43.2	**52**	63	78
13,000,000	20.11	14.40	3.22	32.1	36.8	42.8	50	**60**	73	90
14,000,000	21.66	15.51	3.73	36.9	42.2	49.0	58	**68**	83	103
15,000,000	23.21	16.62	4.29	41.9	48.0	56	66	**78**	95	117

20-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			(00) $c=140$	(0) $c=130$	(5) $c=120$	(11) $c=110$	(19) $c=100$	(28) $c=90$	(41) $c=80$
400,000	0.619	0.28	0.00	0.017	0.020	0.023	0.027	0.032	0.039	0.048
600,000	0.928	0.43	0.00	0.037	0.049	0.049	0.057	0.068	0.083	0.103
800,000	1.238	0.57	0.00	0.062	0.071	0.082	0.097	0.115	0.140	0.174
1,000,000	1.547	0.71	0.01	0.094	0.107	0.124	0.146	0.174	0.211	0.263
1,200,000	1.857	0.85	0.01	0.131	0.150	0.174	0.205	0.243	0.297	0.370
1,400,000	2.166	0.99	0.02	0.174	0.200	0.232	0.273	0.326	0.396	0.491
1,600,000	2.476	1.13	0.02	0.223	0.257	0.298	0.349	0.416	0.51	0.63
1,800,000	2.785	1.28	0.03	0.278	0.319	0.370	0.435	0.52	0.63	0.78
2,000,000	3.094	1.42	0.03	0.339	0.389	0.449	0.53	0.63	0.76	0.96
2,500,000	3.868	1.77	0.05	0.51	0.58	0.68	0.80	0.95	1.16	1.44
3,000,000	4.642	2.13	0.07	0.72	0.82	0.95	1.12	1.33	1.61	2.02
3,500,000	5.41	2.48	0.10	0.95	1.09	1.27	1.49	1.78	2.16	2.69
4,000,000	6.19	2.84	0.13	1.22	1.39	1.62	1.90	2.28	2.77	3.44
4,500,000	6.96	3.19	0.16	1.52	1.74	2.02	2.38	2.83	3.44	4.29
5,000,000	7.74	3.55	0.20	1.84	2.11	2.45	2.88	3.43	4.18	5.2
5,500,000	8.51	3.90	0.24	2.20	2.52	2.92	3.43	4.09	4.98	6.2
6,000,000	9.28	4.26	0.28	2.59	2.97	3.44	4.03	4.81	5.8	7.3
6,500,000	10.06	4.61	0.33	3.00	3.43	3.99	4.68	5.6	6.8	8.4
7,000,000	10.83	4.96	0.38	3.43	3.95	4.58	5.4	6.4	7.8	9.7
7,500,000	11.60	5.32	0.44	3.90	4.48	5.2	6.1	7.3	8.8	11.0
8,000,000	12.38	5.67	0.50	4.39	5.1	5.8	6.9	8.2	10.0	12.4
8,500,000	13.15	6.03	0.56	4.91	5.6	6.6	7.7	9.2	11.2	13.8
9,000,000	13.92	6.38	0.63	5.5	6.3	7.3	8.6	10.2	12.4	15.4
9,500,000	14.70	6.74	0.71	6.0	6.9	8.0	9.4	11.3	13.7	17.1
10,000,000	15.47	7.09	0.78	6.6	7.6	8.9	10.4	12.4	15.1	18.7
11,000,000	17.02	7.80	0.94	7.9	9.1	10.6	12.4	14.8	18.0	22.4
12,000,000	18.57	8.51	1.12	9.4	10.7	12.4	14.6	17.4	21.1	26.2
13,000,000	20.11	9.22	1.32	10.8	12.4	14.4	16.9	20.1	24.4	30.4
14,000,000	21.66	9.93	1.53	12.4	14.2	16.5	19.4	23.1	28.1	35.0
15,000,000	23.21	10.64	1.76	14.1	16.2	18.8	22.0	26.2	32.0	39.8
16,000,000	24.76	11.35	2.00	15.8	18.2	21.1	24.8	29.6	36.0	44.8
17,000,000	26.30	12.06	2.25	17.7	20.4	23.8	27.9	33.1	40.2	50
18,000,000	27.85	12.77	2.53	19.7	22.7	26.2	30.9	36.8	44.7	56
19,000,000	29.40	13.47	2.82	21.8	25.0	29.1	34.1	40.7	49.5	62
20,000,000	30.94	14.18	3.13	24.0	27.6	32.0	37.5	44.8	54	68

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 $c=140$	0 $c=130$	5 $c=120$	11 $c=110$	19 $c=100$	29 $c=90$	42 $c=80$
500,000	0.774	0.25	0.00	0.011	0.012	0.014	0.017	**0.020**	0.024	0.030
1,000,000	1.547	0.49	0.00	0.038	0.044	0.051	0.060	**0.072**	0.087	0.108
1,500,000	2.321	0.74	0.01	0.082	0.093	0.108	0.128	**0.152**	0.185	0.230
2,000,000	3.094	0.98	0.01	0.138	0.159	0.185	0.218	**0.259**	0.314	0.391
2,500,000	3.868	1.23	0.02	0.210	0.240	0.279	0.328	**0.390**	0.474	0.59
3,000,000	4.642	1.48	0.03	0.293	0.338	0.391	0.459	**0.55**	0.66	0.83
3,500,000	5.41	1.72	0.03	0.391	0.449	0.52	0.61	**0.73**	0.89	1.11
4,000,000	6.19	1.97	0.05	0.50	0.58	0.67	0.78	**0.93**	1.13	1.42
4,500,000	6.96	2.22	0.06	0.62	0.72	0.83	0.98	**1.16**	1.42	1.76
5,000,000	7.74	2.46	0.09	0.76	0.87	1.02	1.18	**1.41**	1.72	2.14
5,500,000	8.51	2.71	0.11	0.90	1.03	1.21	1.42	**1.68**	2.05	2.56
6,000,000	9.28	2.96	0.14	1.06	1.22	1.42	1.66	**1.97**	2.41	2.99
6,500,000	10.06	3.20	0.16	1.23	1.41	1.64	1.93	**2.29**	2.79	3.48
7,000,000	10.83	3.45	0.18	1.41	1.62	1.88	2.21	**2.63**	3.20	3.98
7,500,000	11.60	3.69	0.21	1.61	1.84	2.13	2.51	**2.98**	3.63	4.52
8,000,000	12.38	3.94	0.24	1.81	2.07	2.41	2.83	**3.38**	4.09	5.1
8,500,000	13.15	4.19	0.27	2.02	2.32	2.68	3.16	**3.77**	4.58	5.7
9,000,000	13.92	4.43	0.31	2.26	2.58	2.99	3.52	**4.20**	5.1	6.4
9,500,000	14.70	4.68	0.34	2.48	2.85	3.31	3.89	**4.62**	5.6	7.0
10,000,000	15.47	4.92	0.38	2.73	3.12	3.63	4.28	**5.1**	6.2	7.7
11,000,000	17.02	5.42	0.46	3.26	3.74	4.33	5.1	**6.1**	7.4	9.2
12,000,000	18.57	5.91	0.54	3.82	4.39	5.1	6.0	**7.1**	8.7	10.8
13,000,000	20.11	6.40	0.64	4.45	5.1	5.9	6.9	**8.3**	10.1	12.6
14,000,000	21.66	6.89	0.74	5.1	5.8	6.8	8.0	**9.5**	11.6	14.3
15,000,000	23.21	7.39	0.85	5.8	6.6	7.7	9.1	**10.8**	13.2	16.3
16,000,000	24.76	7.88	0.96	6.6	7.5	8.7	10.2	**12.2**	14.8	18.4
17,000,000	26.30	8.37	1.09	7.3	8.4	9.7	11.4	**13.6**	16.6	20.7
18,000,000	27.85	8.86	1.22	8.1	9.3	10.8	12.7	**15.2**	18.4	22.9
19,000,000	29.40	9.36	1.36	9.0	10.3	11.9	14.0	**16.7**	20.3	25.3
20,000,000	30.94	9.85	1.51	9.9	11.3	13.2	15.4	**18.3**	22.4	27.8
22,000,000	34.04	10.83	1.82	11.8	13.5	15.7	18.4	**21.9**	26.7	33.1
24,000,000	37.13	11.82	2.17	13.8	15.8	18.4	21.7	**25.9**	31.2	39.0
26,000,000	40.23	12.80	2.55	16.1	18.4	21.3	25.0	**29.9**	36.4	45.2
28,000,000	43.32	13.79	2.96	18.3	21.1	24.5	28.8	**34.2**	41.9	52
30,000,000	46.42	14.77	3.38	20.9	24.0	27.9	32.8	**39.0**	47.5	59

30-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Gallons per 24 Hours.	Cubic Feet per Second.			00 $c=140$	0 $c=130$	6 $c=120$	12 $c=110$	19 $c=100$	30 $c=90$	43 $c=80$
1,000,000	1.547	0.32	0.00	0.013	0.015	0.017	0.020	**0.024**	0.029	0.037
1,500,000	2.321	0.47	0.00	0.028	0.032	0.037	0.044	**0.052**	0.062	0.078
2,000,000	3.094	0.63	0.01	0.047	0.054	0.062	0.073	**0.087**	0.106	0.132
2,500,000	3.868	0.89	0.01	0.071	0.081	0.094	0.111	**0.132**	0.160	0.199
3,000,000	4.642	0.95	0.01	0.099	0.113	0.132	0.155	**0.184**	0.225	0.280
3,500,000	5.41	1.10	0.02	0.132	0.151	0.176	0.206	**0.247**	0.298	0.372
4,000,000	6.19	1.26	0.02	0.168	0.194	0.225	0.264	**0.315**	0.382	0.477
4,500,000	6.96	1.42	0.03	0.210	0.241	0.279	0.329	**0.391**	0.476	0.59
5,000,000	7.74	1.58	0.04	0.256	0.292	0.340	0.399	**0.476**	0.58	0.72
5,500,000	8.51	1.73	0.05	0.304	0.349	0.405	0.476	**0.57**	0.69	0.88
6,000,000	9.28	1.89	0.06	0.357	0.410	0.475	0.56	**0.67**	0.81	1.01
6,500,000	10.06	2.05	0.07	0.414	0.475	0.55	0.65	**0.78**	0.94	1.17
7,000,000	10.83	2.21	0.08	0.474	0.55	0.64	0.74	**0.89**	1.08	1.34
7,500,000	11.60	2.36	0.09	0.54	0.62	0.72	0.84	**1.01**	1.22	1.53
8,000,000	12.38	2.52	0.10	0.61	0.70	0.81	0.95	**1.13**	1.38	1.72
8,500 000	13.15	2.68	0.11	0.68	0.78	0.91	1.07	**1.27**	1.54	1.92
9,000,000	13.92	2.84	0.13	0.76	0.87	1.01	1.18	**1.42**	1.72	2.14
10,000,000	15.47	3.15	0.15	0.92	1.06	1.23	1.44	**1.72**	2.09	2.60
11,000,000	17.02	3.47	0.19	1.09	1.26	1.46	1.72	**2.06**	2.49	3.10
12,000,000	18.57	3.78	0.22	1.28	1.47	1.72	2.02	**2.41**	2.92	3.64
13,000,000	20.11	4.10	0.26	1.50	1.72	1.98	2.34	**2.79**	3.40	4.21
14,000,000	21.66	4.41	0.30	1.72	1.97	2.28	2.69	**3.20**	3.89	4.85
15,000,000	23.21	4.73	0.35	1.95	2.24	2.60	3.06	**3.64**	4.43	5.5
16,000,000	24.76	5.04	0.40	2.20	2.52	2.93	3.45	**4.10**	4.99	6.2
17,000,000	26.30	5.36	0.45	2.46	2.82	3.28	3.85	**4.59**	5.6	7.0
18,000,000	27.85	5.67	0.50	2.74	3.14	3.63	4.28	**5.1**	6.2	7.7
19,000,000	29.40	5.99	0.56	3.02	3.47	4.01	4.72	**5.6**	6.8	8.6
20,000,000	30.94	6.30	0.62	3.33	3.81	4.44	5.2	**6.2**	7.6	9.4
22,000,000	34.04	6.93	0.75	3.96	4.55	5.3	6.2	**7.4**	9.0	11.2
24,000,000	37.13	7.56	0.89	4.65	5.4	6.2	7.3	**8.7**	10.6	13.2
25							7.8			
26,000,000	40.23	8.20	1.04	5.4	6.2	7.2	8.4	**10.1**	12.3	15.3
28,000,000	43.32	8.83	1.21	6.2	7.1	8.3	9.7	**11.6**	14.1	17.5
30,000,000	46.42	9.46	1.39	7.1	8.1	9.4	11.0	**13.2**	16.0	19.8
35,000,000	54.1	11.03	1.89	9.4	10.8	12.6	14.7	**17.5**	21.3	26.4
40,000,000	61.9	12.61	2.47	12.0	13.8	16.0	18.8	**22.4**	27.2	33.9

36-INCH PIPE.

Discharge in: Million Gallons per 24 Hours.	Discharge in: Cubic Feet per Second.	Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length. 00 $c=140$	0 $c=130$	6 $c=120$	12 $c=110$	20 $c=100$	30 $c=90$	44 $c=80$
2	3.094	0.44	0.00	0.019	0.022	0.026	0.030	**0.036**	0.044	0.054
2.5	3.868	0.55	0.00	0.029	0.033	0.039	0.046	**0.054**	0.066	0.082
3	4.642	0.66	0.01	0.041	0.047	0.054	0.064	**0.076**	0.092	0.115
3.5	5.41	0.77	0.01	0.054	0.062	0.072	0.085	**0.102**	0.123	0.153
4	6.19	0.88	0.01	0.070	0.080	0.092	0.108	**0.129**	0.157	0.196
5	7.74	1.09	0.02	0.105	0.121	0.140	0.164	**0.196**	0.238	0.297
6	9.28	1.31	0.03	0.147	0.168	0.196	0.230	**0.274**	0.333	0.415
7	10.83	1.53	0.04	0.196	0.224	0.260	0.306	**0.365**	0.444	0.55
8	12.38	1.75	0.05	0.250	0.288	0.332	0.391	**0.467**	0.57	0.71
9	13.92	1.97	0.06	0.311	0.358	0.415	0.488	**0.58**	0.71	0.88
10	15.47	2.19	0.07	0.379	0.434	0.50	0.59	**0.71**	0.86	1.07
11	17.02	2.41	0.09	0.451	0.52	0.60	0.70	**0.84**	1.02	1.28
12	18.57	2.63	0.11	0.53	0.61	0.71	0.83	**0.99**	1.21	1.50
13	20.11	2.85	0.13	0.62	0.71	0.82	0.96	**1.15**	1.39	1.74
14	21.66	3.06	0.15	0.71	0.81	0.94	1.11	**1.32**	1.60	1.98
15	23.21	3.28	0.17	0.80	0.92	1.07	1.26	**1.49**	1.82	2.27
16	24.76	3.50	0.19	0.90	1.03	1.21	1.42	**1.68**	2.05	2.56
17	26.30	3.72	0.22	1.02	1.16	1.34	1.58	**1.88**	2.30	2.86
18	27.85	3.94	0.24	1.12	1.29	1.50	1.76	**2.10**	2.56	3.18
19	29.40	4.16	0.27	1.24	1.43	1.66	1.94	**2.32**	2.81	3.51
20	30.94	4.38	0.30	1.37	1.57	1.82	2.14	**2.55**	3.10	3.86
22	34.04	4.82	0.36	1.63	1.87	2.17	2.55	**3.04**	3.69	4.60
24	37.13	5.25	0.43	1.92	2.20	2.55	2.99	**3.58**	4.35	5.4
26	40.23	5.69	0.50	2.22	2.55	2.96	3.48	**4.14**	5.1	6.3
28	43.32	6.13	0.58	2.55	2.92	3.39	3.98	**4.76**	5.8	7.2
30	46.42	6.57	0.67	2.90	3.32	3.86	4.53	**5.4**	6.6	8.2
32	49.51	7.00	0.76	3.27	3.74	4.33	5.1	**6.1**	7.4	9.2
34	52.6	7.44	0.86	3.65	4.19	4.86	5.7	**6.8**	8.3	10.3
36	55.7	7.88	0.96	4.07	4.67	5.4	6.4	**7.6**	9.2	11.4
38	58.8	8.32	1.07	4.50	5.2	6.0	7.0	**8.4**	10.2	12.7
40	61.9	8.76	1.19	4.95	5.7	6.6	7.8	**9.2**	11.2	13.9
45	69.6	9.85	1.50	6.2	7.1	8.2	9.6	**11.4**	13.9	17.4
50	77.4	10.95	1.86	7.5	8.6	10.0	11.7	**13.9**	17.0	21.1
55	85.1	12.04	2.25	8.9	10.2	11.8	13.9	**16.6**	20.2	25.1
60	92.8	13.13	2.68	10.4	12.1	13.9	16.4	**19.6**	23.8	29.7

42-INCH PIPE.

Discharge in: Million Gallons per 24 Hours.	Discharge in: Cubic Feet per Second.	Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length. 00 $c=140$	0 $c=130$	6 $c=120$	12 $c=110$	20 $c=100$	30 $c=90$	45 $c=80$
3	4.64	0.48	0.00	0.019	0.022	0.026	0.030	**0.036**	0.044	0.054
4	6.19	0.64	0.01	0.033	0.038	0.044	0.052	**0.061**	0.074	0.092
5	7.74	0.80	0.01	0.050	0.057	0.066	0.078	**0.092**	0.113	0.140
6	9.28	0.96	0.01	0.070	0.080	0.092	0.108	**0.129**	0.158	0.196
7	10.83	1.13	0.02	0.092	0.106	0.123	0.145	**0.172**	0.210	0.261
8	12.38	1.29	0.03	0.118	0.136	0.158	0.185	**0.220**	0.268	0.333
9	13.92	1.45	0.03	0.147	0.168	0.196	0.230	**0.273**	0.333	0.415
10	15.47	1.61	0.04	0.178	0.207	0.238	0.280	**0.332**	0.406	0.51
11	17.02	1.77	0.05	0.213	0.245	0.284	0.334	**0.398**	0.483	0.60
12	18.57	1.93	0.06	0.251	0.288	0.333	0.392	**0.468**	0.57	0.71
14	21.66	2.25	0.08	0.333	0.382	0.445	0.52	**0.62**	0.76	0.94
16	24.76	2.57	0.10	0.428	0.490	0.57	0.67	**0.80**	0.97	1.21
18	27.85	2.89	0.13	0.53	0.61	0.71	0.83	**0.99**	1.21	1.50
20	30.94	3.22	0.16	0.64	0.74	0.86	1.02	**1.21**	1.47	1.83
22	34.04	3.53	0.19	0.77	0.88	1.03	1.21	**1.44**	1.74	2.18
24	37.13	3.86	0.23	0.90	1.04	1.21	1.42	**1.68**	2.05	2.55
26	40.23	4.18	0.27	1.05	1.21	1.39	1.64	**1.96**	2.38	2.97
28	43.32	4.50	0.31	1.21	1.38	1.61	1.88	**2.25**	2.74	3.40
30	46.42	4.82	0.36	1.37	1.57	1.83	2.14	**2.56**	3.10	3.87
32	49.51	5.15	0.41	1.54	1.77	2.06	2.41	**2.88**	3.50	4.36
34	52.6	5.47	0.46	1.73	1.98	2.29	2.70	**3.21**	3.91	4.88
36	55.7	5.79	0.52	1.92	2.20	2.56	3.00	**3.58**	4.35	5.4
38	58.8	6.11	0.58	2.12	2.43	2.82	3.31	**3.95**	4.80	6.0
40	61.9	6.45	0.64	2.33	2.68	3.10	3.64	**4.35**	5.3	6.6
42	65.0	6.75	0.71	2.56	2.92	3.40	3.99	**4.76**	5.8	7.2
44	68.1	7.08	0.78	2.78	3.19	3.70	4.36	**5.2**	6.3	7.8
46	71.2	7.40	0.85	3.02	3.48	4.02	4.71	**5.6**	6.8	8.5
48	74.3	7.72	0.93	3.28	3.76	4.36	5.1	**6.1**	7.4	9.2
50	77.4	8.04	1.01	3.52	4.05	4.70	5.5	**6.6**	8.0	10.0
55	85.1	8.84	1.21	4.21	4.82	5.6	6.6	**7.8**	9.6	11.8
60	92.8	9.65	1.45	4.94	5.7	6.6	7.7	**9.2**	11.2	13.9
65	100.6	10.45	1.70	5.7	6.6	7.6	9.0	**10.7**	13.0	16.2
70	108.3	11.26	1.97	6.6	7.6	8.8	10.3	**12.2**	14.9	18.6
75	116.0	12.06	2.26	7.5	8.6	10.0	11.7	**13.9**	16.9	21.1
80	123.8	12.86	2.57	8.4	9.6	11.2	13.2	**15.7**	19.1	23.8

$V^2 = 2gh$

$/2g$

48-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Million Gallons per 24 Hours.	Cubic Feet per Second.			00 c=140	0 c=130	6 c=120	12 c=110	20 c=100	30 c=90	45 c=80
4	6.19	0.49	0.00	0.017	0.020	0.023	0.027	**0.032**	0.039	0.048
5	7.74	0.62	0.01	0.026	0.030	0.035	0.041	**0.048**	0.059	0.073
6	9.28	0.74	0.01	0.036	0.042	0.048	0.057	**0.068**	0.082	0.102
8	12.38	0.98	0.01	0.062	0.071	0.082	0.097	**0.115**	0.140	0.174
10	15.47	1.23	0.02	0.094	0.107	0.124	0.146	**0.174**	0.212	0.263
12	18.57	1.48	0.03	0.131	0.150	0.174	0.204	**0.243**	0.297	0.369
14	21.66	1.72	0.05	0.174	0.199	0.232	0.272	**0.324**	0.395	0.490
16	24.76	1.97	0.06	0.222	0.256	0.298	0.349	**0.417**	0.51	0.63
18	27.85	2.22	0.08	0.277	0.319	0.369	0.433	**0.52**	0.63	0.78
20	30.94	2.46	0.09	0.338	0.387	0.449	0.53	**0.63**	0.76	0.95
22	34.04	2.71	0.11	0.401	0.460	0.54	0.63	**0.75**	0.91	1.13
24	37.13	2.96	0.14	0.472	0.54	0.63	0.74	**0.88**	1.07	1.33
26	40.23	3.20	0.16	0.55	0.63	0.73	0.86	**1.02**	1.24	1.54
28	43.32	3.45	0.18	0.63	0.72	0.84	0.98	**1.17**	1.43	1.77
30	46.42	3.69	0.21	0.72	0.82	0.95	1.12	**1.33**	1.62	2.02
32	49.51	3.94	0.24	0.80	0.92	1.07	1.26	**1.50**	1.83	2.27
34	52.6	4.19	0.27	0.90	1.03	1.19	1.41	**1.68**	2.03	2.54
36	55.7	4.43	0.31	1.00	1.15	1.33	1.57	**1.87**	2.28	2.82
38	58.8	4.68	0.34	1.11	1.27	1.48	1.73	**2.07**	2.51	3.12
40	61.9	4.92	0.38	1.22	1.39	1.62	1.90	**2.28**	2.77	3.44
42	65.0	5.17	0.41	1.33	1.53	1.77	2.08	**2.49**	3.02	3.76
44	68.1	5.42	0.45	1.45	1.67	1.93	2.28	**2.71**	3.29	4.10
46	71.2	5.66	0.50	1.58	1.81	2.09	2.47	**2.94**	3.58	4.45
48	74.3	5.91	0.54	1.71	1.96	2.28	2.67	**3.19**	3.88	4.81
50	77.4	6.16	0.59	1.84	2.12	2.46	2.88	**3.44**	4.18	5.2
55	85.1	6.77	0.71	2.19	2.52	2.92	3.43	**4.09**	4.97	6.2
60	92.8	7.39	0.85	2.58	2.97	3.44	4.04	**4.80**	5.9	7.3
65	100.6	8.00	0.99	2.99	3.43	3.98	4.68	**5.6**	6.8	8.4
70	108.3	8.62	1.15	3.43	3.94	4.58	5.4	**6.4**	7.8	9.7
75	116.0	9.23	1.32	3.90	4.48	5.2	6.1	**7.3**	8.8	11.0
80	123.8	9.85	1.51	4.40	5.1	5.9	6.9	**8.2**	10.0	12.4
85	131.5	10.48	1.70	4.92	5.6	6.6	7.7	**9.2**	11.2	13.8
90	139.2	11.08	1.91	5.5	6.3	7.3	8.6	**10.2**	12.4	15.4
95	147.0	11.69	2.12	6.0	7.0	8.0	9.5	**11.3**	13.7	17.1
100	154.7	12.31	2.35	6.7	7.6	8.8	10.4	**12.4**	15.1	18.8

54-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Million Gallons per 24 Hours.	Cubic Feet per Second.			(00) $c=140$	(0) $c=130$	(6) $c=120$	(12) $c=110$	(20) $c=100$	(31) $c=90$	(46) $c=80$
6	9.28	0.58	0.01	0.020	0.023	0.027	0.032	**0.038**	0.046	0.058
8	12.38	0.78	0.01	0.035	0.040	0.046	0.054	**0.065**	0.079	0.098
10	15.47	0.97	0.01	0.053	0.060	0.070	0.082	**0.098**	0.119	0.148
12	18.57	1.17	0.02	0.074	0.085	0.098	0.115	**0.137**	0.167	0.208
14	21.66	1.36	0.03	0.098	0.113	0.131	0.153	**0.183**	0.222	0.277
16	24.76	1.56	0.04	0.126	0.144	0.167	0.196	**0.235**	0.285	0.355
18	27.85	1.75	0.05	0.157	0.179	0.208	0.244	**0.291**	0.354	0.440
20	30.94	1.95	0.06	0.190	0.218	0.252	0.297	**0.354**	0.430	0.54
22	34.04	2.14	0.07	0.227	0.260	0.301	0.354	**0.422**	0.52	0.64
24	37.13	2.33	0.08	0.267	0.306	0.354	0.417	**0.496**	0.60	0.75
26	40.23	2.53	0.10	0.309	0.354	0.411	0.482	**0.58**	0.70	0.87
28	43.32	2.72	0.11	0.353	0.406	0.470	0.55	**0.66**	0.80	1.00
30	46.42	2.92	0.13	0.402	0.461	0.54	0.63	**0.75**	0.92	1.13
32	49.51	3.11	0.15	0.453	0.52	0.60	0.71	**0.85**	1.03	1.28
34	52.6	3.31	0.17	0.51	0.58	0.68	0.80	**0.95**	1.15	1.43
36	55.7	3.50	0.19	0.56	0.65	0.75	0.88	**1.05**	1.28	1.59
38	58.8	3.70	0.21	0.62	0.72	0.83	0.98	**1.17**	1.42	1.76
40	61.9	3.89	0.23	0.68	0.79	0.91	1.07	**1.28**	1.55	1.93
42	65.0	4.09	0.26	0.75	0.86	1.00	1.17	**1.40**	1.70	2.12
44	68.1	4.28	0.28	0.82	0.94	1.08	1.28	**1.53**	1.86	2.31
46	71.2	4.47	0.31	0.89	1.02	1.18	1.39	**1.66**	2.02	2.50
48	74.3	4.67	0.34	0.96	1.11	1.28	1.51	**1.79**	2.19	2.72
50	77.4	4.86	0.37	1.04	1.19	1.38	1.62	**1.94**	2.36	2.92
55	85.1	5.35	0.44	1.24	1.42	1.64	1.93	**2.30**	2.80	3.49
60	92.8	5.84	0.53	1.46	1.67	1.93	2.28	**2.71**	3.30	4.10
65	100.6	6.32	0.62	1.68	1.93	2.24	2.63	**3.14**	3.82	4.76
70	108.3	6.81	0.72	1.93	2.22	2.58	3.02	**3.61**	4.39	5.4
75	116.0	7.30	0.83	2.20	2.52	2.92	3.43	**4.10**	4.99	6.2
80	123.8	7.78	0.94	2.48	2.84	3.30	3.88	**4.61**	5.6	7.0
85	131.5	8.27	1.06	2.78	3.18	3.69	4.32	**5.2**	6.3	7.8
90	139.2	8.76	1.19	3.08	3.52	4.10	4.81	**5.8**	7.0	8.7
95	147.0	9.24	1.33	3.41	3.91	4.53	5.4	**6.4**	7.8	9.6
100	154.7	9.73	1.47	3.75	4.30	4.99	5.9	**7.0**	8.5	10.7
110	170.2	10.70	1.78	4.48	5.2	6.0	7.0	**8.4**	10.2	12.7
120	185.7	11.67	2.12	5.3	6.0	7.0	8.2	**9.8**	11.9	14.8

60-INCH PIPE.

Discharge in: Million Gallons per 24 Hours.	Discharge in: Cubic Feet per Second.	Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length. (00) $c=140$	(0) $c=130$	(6) $c=120$	(12) $c=110$	(20) $c=100$	(31) $c=90$	(47) $c=80$
4	6.19	0.32	0.00	0.006	0.007	0.008	0.009	**0.011**	0.013	0.016
6	9.28	0.47	0.00	0.012	0.014	0.016	0.019	**0.023**	0.028	0.035
8	12.38	0.63	0.01	0.021	0.024	0.028	0.033	**0.039**	0.047	0.059
10	15.47	0.79	0.01	0.032	0.036	0.042	0.049	**0.059**	0.072	0.089
12	18.57	0.95	0.01	0.044	0.051	0.059	0.069	**0.082**	0.100	0.124
14	21.66	1.10	0.02	0.059	0.068	0.078	0.092	**0.109**	0.133	0.166
16	24.76	1.26	0.02	0.075	0.086	0.100	0.117	**0.140**	0.171	0.212
18	27.85	1.42	0.03	0.094	0.107	0.124	0.146	**0.174**	0.212	0.263
20	30.94	1.58	0.04	0.113	0.131	0.152	0.178	**0.212**	0.258	0.320
22	34.04	1.73	0.05	0.136	0.156	0.181	0.212	**0.253**	0.308	0.381
24	37.13	1.89	0.06	0.159	0.183	0.212	0.249	**0.298**	0.361	0.449
26	40.23	2.05	0.07	0.185	0.212	0.247	0.289	**0.346**	0.419	0.52
28	43.32	2.21	0.08	0.212	0.243	0.282	0.331	**0.395**	0.480	0.60
30	46.42	2.36	0.09	0.241	0.277	0.320	0.377	**0.449**	0.55	0.68
32	49.51	2.52	0.10	0.271	0.310	0.361	0.425	**0.51**	0.62	0.76
34	52.6	2.68	0.11	0.303	0.349	0.404	0.474	**0.57**	0.69	0.86
36	55.7	2.84	0.12	0.338	0.388	0.449	0.53	**0.63**	0.76	0.95
38	58.8	2.99	0.14	0.372	0.428	0.496	0.58	**0.70**	0.85	1.05
40	61.9	3.15	0.15	0.410	0.470	0.55	0.64	**0.76**	0.93	1.16
45	69.6	3.55	0.19	0.51	0.59	0.68	0.80	**0.95**	1.16	1.44
50	77.4	3.94	0.24	0.62	0.71	0.83	0.97	**1.16**	1.41	1.75
55	85.1	4.33	0.29	0.74	0.85	0.98	1.16	**1.38**	1.68	2.09
60	92.8	4.73	0.35	0.87	1.00	1.16	1.36	**1.62**	1.98	2.46
65	100.6	5.12	0.41	1.02	1.16	1.34	1.58	**1.88**	2.29	2.85
70	108.3	5.52	0.47	1.16	1.33	1.54	1.81	**2.17**	2.62	3.28
75	116.0	5.91	0.54	1.32	1.51	1.75	2.06	**2.46**	2.98	3.70
80	123.8	6.30	0.62	1.48	1.70	1.97	2.31	**2.78**	3.37	4.19
85	131.5	6.70	0.70	1.66	1.90	2.21	2.59	**3.09**	3.75	4.68
90	139.2	7.09	0.78	1.84	2.12	2.47	2.89	**3.44**	4.19	5.2
95	147.0	7.49	0.87	2.03	2.34	2.71	3.19	**3.80**	4.61	5.8
100	154.7	7.88	0.97	2.24	2.57	2.98	3.51	**4.19**	5.1	6.4
110	170.2	8.67	1.17	2.68	3.07	3.57	4.18	**4.98**	6.0	7.6
120	185.7	9.46	1.39	3.13	3.60	4.18	4.90	**5.9**	7.1	8.9
130	201.1	10.24	1.63	3.63	4.18	4.84	5.7	**6.8**	8.3	10.3
140	216.6	11.03	1.89	4.18	4.79	5.6	6.6	**7.8**	9.5	11.8

66-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Million Gallons per 24 Hours.	Cubic Feet per Second.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
8	12.38	0.52	0.00	0.013	0.015	0.017	0.021	**0.024**	0.030	0.037
10	15.47	0.65	0.01	0.020	0.023	0.026	0.031	**0.037**	0.045	0.056
12	18.57	0.78	0.01	0.028	0.032	0.037	0.043	**0.052**	0.063	0.078
14	21.66	0.91	0.01	0.037	0.042	0.049	0.058	**0.069**	0.084	0.104
16	24.76	1.04	0.02	0.047	0.054	0.063	0.074	**0.088**	0.107	0.133
18	27.85	1.17	0.02	0.059	0.068	0.078	0.092	**0.109**	0.133	0.166
20	30.94	1.30	0.03	0.071	0.082	0.095	0.112	**0.133**	0.162	0.202
22	34.04	1.43	0.03	0.085	0.098	0.113	0.133	**0.158**	0.193	0.240
24	37.13	1.56	0.04	0.100	0.115	0.133	0.157	**0.187**	0.228	0.283
26	40.23	1.69	0.04	0.116	0.133	0.154	0.182	**0.217**	0.262	0.328
28	43.32	1.82	0.05	0.133	0.153	0.178	0.208	**0.248**	0.302	0.376
30	46.42	1.95	0.06	0.152	0.173	0.201	0.237	**0.282**	0.343	0.427
32	49.51	2.08	0.07	0.171	0.196	0.227	0.267	**0.318**	0.388	0.480
34	52.6	2.21	0.08	0.191	0.219	0.254	0.298	**0.356**	0.432	0.54
36	55.7	2.34	0.09	0.212	0.243	0.282	0.331	**0.396**	0.481	0.60
38	58.8	2.47	0.10	0.235	0.269	0.312	0.368	**0.438**	0.53	0.66
40	61.9	2.60	0.11	0.258	0.296	0.344	0.403	**0.481**	0.59	0.73
45	69.6	2.93	0.13	0.320	0.368	0.427	0.50	**0.60**	0.73	0.90
50	77.4	3.26	0.16	0.390	0.448	0.52	0.61	**0.73**	0.88	1.10
55	85.1	3.58	0.20	0.466	0.53	0.62	0.73	**0.87**	1.06	1.32
60	92.8	3.91	0.24	0.55	0.63	0.73	0.86	**1.02**	1.24	1.54
65	100.6	4.23	0.28	0.64	0.73	0.84	0.99	**1.18**	1.44	1.79
70	108.3	4.56	0.32	0.73	0.84	0.97	1.14	**1.36**	1.65	2.06
75	116.0	4.88	0.37	0.83	0.95	1.10	1.29	**1.54**	1.87	2.33
80	123.8	5.21	0.42	0.93	1.07	1.24	1.46	**1.74**	2.11	2.63
85	131.5	5.53	0.47	1.04	1.19	1.38	1.63	**1.94**	2.37	2.94
90	139.2	5.86	0.53	1.16	1.33	1.54	1.82	**2.17**	2.63	3.28
95	147.0	6.19	0.59	1.28	1.47	1.71	2.00	**2.39**	2.90	3.61
100	154.7	6.51	0.66	1.41	1.62	1.88	2.20	**2.62**	3.20	3.98
110	170.2	7.16	0.80	1.67	1.92	2.22	2.61	**3.12**	3.80	4.71
120	185.7	7.81	0.95	1.97	2.27	2.62	3.09	**3.68**	4.48	5.6
130	201.1	8.47	1.11	2.29	2.62	3.04	3.59	**4.28**	5.2	6.4
140	216.6	9.12	1.29	2.62	3.01	3.50	4.11	**4.90**	6.0	7.4
150	232.1	9.77	1.48	2.99	3.43	3.98	4.68	**5.6**	6.8	8.4
160	247.6	10.42	1.68	3.37	3.87	4.49	5.3	**6.3**	7.6	9.5

72-INCH PIPE.

Discharge in				Loss of Head in Feet per 1000 feet of length.						
Million Gallons per 24 Hours.	Cubic Feet per Second.	Velocity in Feet per Second.	Velocity Head, Feet.	Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
8	12.38	0.44	0.00	0.009	0.010	0.011	0.013	**0.016**	0.019	0.024
10	15.47	0.55	0.00	0.013	0.015	0.017	0.020	**0.024**	0.029	0.037
12	18.57	0.66	0.01	0.018	0.021	0.024	0.028	**0.034**	0.041	0.051
14	21.66	0.77	0.01	0.024	0.028	0.032	0.038	**0.045**	0.055	0.068
16	24.76	0.88	0.01	0.031	0.035	0.041	0.048	**0.058**	0.070	0.088
18	27.85	0.98	0.02	0.038	0.044	0.051	0.060	**0.072**	0.087	0.108
20	30.94	1.09	0.02	0.047	0.054	0.062	0.073	**0.087**	0.106	0.132
22	34.04	1.20	0.02	0.056	0.064	0.074	0.087	**0.104**	0.126	0.157
24	37.13	1.31	0.03	0.066	0.075	0.087	0.103	**0.122**	0.148	0.185
26	40.23	1.42	0.03	0.076	0.087	0.102	0.118	**0.142**	0.172	0.215
28	43.32	1.53	0.04	0.087	0.100	0.116	0.136	**0.162**	0.197	0.246
30	46.42	1.64	0.04	0.099	0.113	0.132	0.155	**0.185**	0.225	0.279
32	49.51	1.75	0.05	0.112	0.128	0.148	0.174	**0.208**	0.252	0.315
34	52.6	1.86	0.05	0.125	0.143	0.166	0.195	**0.232**	0.282	0.351
36	55.7	1.97	0.06	0.138	0.159	0.185	0.217	**0.259**	0.315	0.391
38	58.8	2.08	0.07	0.153	0.176	0.204	0.240	**0.287**	0.348	0.432
40	61.9	2.19	0.07	0.169	0.193	0.225	0.263	**0.315**	0.382	0.476
45	69.6	2.46	0.09	0.210	0.241	0.280	0.329	**0.391**	0.477	0.59
50	77.4	2.74	0.12	0.255	0.292	0.340	0.399	**0.477**	0.58	0.72
55	81.5	3.01	0.14	0.304	0.349	0.405	0.476	**0.57**	0.69	0.86
60	92.8	3.28	0.17	0.358	0.410	0.476	0.56	**0.67**	0.81	1.02
65	100.6	3.56	0.20	0.414	0.475	0.55	0.65	**0.78**	0.94	1.17
70	108.3	3.83	0.23	0.476	0.55	0.64	0.74	**0.88**	1.08	1.34
75	116.0	4.10	0.26	0.54	0.62	0.72	0.84	**1.01**	1.23	1.53
80	123.8	4.38	0.30	0.61	0.70	0.81	0.96	**1.14**	1.38	1.72
90	139.2	4.92	0.38	0.76	0.87	1.01	1.18	**1.42**	1.72	2.14
100	154.7	5.47	0.47	0.92	1.07	1.23	1.44	**1.72**	2.10	2.60
110	170.2	6.02	0.56	1.10	1.27	1.47	1.72	**2.05**	2.49	3.10
120	185.7	6.57	0.67	1.28	1.48	1.72	2.01	**2.40**	2.92	3.64
130	201.1	7.11	0.79	1.50	1.72	1.99	2.34	**2.79**	3.40	4.21
140	216.6	7.66	0.91	1.72	1.97	2.29	2.69	**3.20**	3.90	4.84
150	232.1	8.21	1.05	1.95	2.24	2.60	3.05	**3.62**	4.41	5.5
160	247.6	8.76	1.19	2.20	2.52	2.92	3.43	**4.10**	4.99	6.2
170	263.0	9.30	1.34	2.46	2.82	3.28	3.85	**4.59**	5.6	7.0
180	278.5	9.85	1.51	2.73	3.13	3.63	4.29	**5.1**	6.2	7.8

78-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
10	6.46	0.30	0.00	0.004	0.004	0.005	0.006	**0.007**	0.009	0.011
15	9.69	0.45	0.00	0.008	0.009	0.011	0.013	**0.015**	0.019	0.023
20	12.93	0.60	0.01	0.014	0.016	0.019	0.022	**0.026**	0.032	0.040
25	16.16	0.75	0.01	0.021	0.024	0.028	0.033	**0.040**	0.048	0.060
30	19.39	0.90	0.01	0.030	0.034	0.040	0.047	**0.056**	0.068	0.084
35	22.62	1.05	0.02	0.040	0.046	0.053	0.062	**0.074**	0.090	0.112
40	25.85	1.21	0.02	0.051	0.058	0.068	0.080	**0.095**	0.116	0.144
45	29.08	1.36	0.03	0.064	0.073	0.084	0.099	**0.118**	0.144	0.178
50	32.32	1.51	0.04	0.077	0.088	0.102	0.120	**0.143**	0.174	0.218
55	35.55	1.66	0.04	0.092	0.106	0.122	0.144	**0.172**	0.208	0.259
60	38.78	1.81	0.05	0.108	0.124	0.144	0.169	**0.201**	0.245	0.304
65	42.01	1.96	0.06	0.126	0.144	0.167	0.196	**0.233**	0.284	0.354
70	45.24	2.11	0.07	0.143	0.164	0.190	0.223	**0.268**	0.325	0.404
75	48.47	2.26	0.08	0.163	0.186	0.217	0.253	**0.303**	0.369	0.459
80	51.7	2.41	0.09	0.184	0.211	0.246	0.288	**0.343**	0.419	0.52
85	54.9	2.56	0.10	0.205	0.236	0.272	0.321	**0.382**	0.467	0.58
90	58.2	2.71	0.11	0.228	0.262	0.304	0.358	**0.426**	0.52	0.64
95	61.4	2.86	0.13	0.252	0.290	0.337	0.396	**0.471**	0.57	0.72
100	64.6	3.01	0.14	0.278	0.319	0.369	0.432	**0.52**	0.63	0.78
110	71.1	3.32	0.17	0.331	0.379	0.440	0.52	**0.62**	0.75	0.94
120	77.5	3.62	0.20	0.389	0.446	0.52	0.61	**0.72**	0.88	1.09
130	84.0	3.92	0.24	0.450	0.52	0.60	0.71	**0.84**	1.02	1.27
140	90.5	4.22	0.28	0.52	0.59	0.69	0.81	**0.96**	1.17	1.46
150	96.9	4.52	0.32	0.59	0.68	0.78	0.92	**1.09**	1.33	1.66
160	103.4	4.82	0.36	0.66	0.76	0.88	1.03	**1.23**	1.50	1.87
170	109.9	5.12	0.41	0.74	0.85	0.99	1.16	**1.38**	1.68	2.09
180	116.3	5.43	0.46	0.82	0.94	1.09	1.28	**1.54**	1.87	2.32
190	122.8	5.73	0.51	0.91	1.04	1.22	1.43	**1.70**	2.07	2.58
200	129.3	6.03	0.56	1.00	1.15	1.33	1.57	**1.87**	2.27	2.82
220	142.2	6.63	0.68	1.19	1.37	1.59	1.87	**2.22**	2.70	3.38
240	155.1	7.23	0.81	1.40	1.61	1.87	2.20	**2.62**	3.19	3.97
260	168.0	7.84	0.95	1.63	1.87	2.17	2.54	**3.04**	3.69	4.59
280	181.0	8.44	1.11	1.87	2.14	2.49	2.92	**3.49**	4.23	5.3
300	193.9	9.04	1.27	2.12	2.43	2.82	3.31	**3.96**	4.80	6.0
320	206.8	9.64	1.44	2.39	2.75	3.19	3.74	**4.45**	5.4	6.8

84-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
10	6.46	0.26	0.00	0.003	0.003	0.004	0.004	0.005	0.006	0.008
15	9.69	0.39	0.00	0.006	0.007	0.008	0.009	0.011	0.013	0.016
20	12.93	0.52	0.00	0.010	0.011	0.013	0.015	0.018	0.022	0.028
25	16.16	0.65	0.01	0.015	0.017	0.020	0.023	0.028	0.034	0.042
30	19.39	0.78	0.01	0.021	0.024	0.028	0.033	0.039	0.047	0.059
35	22.62	0.91	0.01	0.028	0.032	0.037	0.043	0.052	0.063	0.078
40	25.85	1.04	0.02	0.036	0.041	0.047	0.056	0.066	0.080	0.100
45	29.08	1.17	0.02	0.044	0.051	0.059	0.069	0.082	0.100	0.124
50	32.32	1.30	0.03	0.054	0.062	0.072	0.084	0.100	0.122	0.152
55	35.55	1.43	0.03	0.064	0.074	0.086	0.100	0.119	0.145	0.181
60	38.78	1.56	0.04	0.075	0.086	0.100	0.118	0.141	0.171	0.212
65	42.01	1.69	0.04	0.087	0.100	0.117	0.136	0.163	0.198	0.247
70	45.24	1.82	0.05	0.100	0.114	0.133	0.157	0.187	0.228	0.282
80	51.7	2.08	0.07	0.128	0.147	0.171	0.200	0.239	0.290	0.361
90	58.2	2.34	0.09	0.159	0.183	0.212	0.249	0.297	0.361	0.450
100	64.6	2.60	0.11	0.193	0.222	0.257	0.302	0.361	0.439	0.55
110	71.1	2.86	0.13	0.231	0.265	0.307	0.361	0.430	0.52	0.65
120	77.5	3.12	0.15	0.272	0.311	0.361	0.424	0.51	0.62	0.76
130	84.0	3.38	0.18	0.314	0.361	0.419	0.492	0.59	0.71	0.89
140	90.5	3.64	0.21	0.361	0.414	0.480	0.56	0.68	0.82	1.04
150	96.9	3.90	0.24	0.410	0.470	0.54	0.64	0.77	0.93	1.16
160	103.4	4.16	0.27	0.461	0.53	0.62	0.72	0.86	1.04	1.30
170	109.9	4.42	0.30	0.52	0.60	0.69	0.81	0.96	1.17	1.46
180	116.3	4.68	0.34	0.58	0.66	0.76	0.90	1.07	1.30	1.62
190	122.8	4.94	0.38	0.64	0.73	0.84	0.99	1.18	1.44	1.79
200	129.3	5.20	0.42	0.70	0.80	0.93	1.09	1.30	1.58	1.97
220	142.2	5.72	0.51	0.83	0.96	1.11	1.30	1.55	1.88	2.35
240	155.1	6.24	0.60	0.98	1.12	1.30	1.53	1.82	2.21	2.77
260	168.0	6.76	0.71	1.13	1.30	1.51	1.77	2.11	2.57	3.20
280	181.0	7.28	0.82	1.30	1.49	1.73	2.03	2.42	2.96	3.68
300	193.9	7.80	0.94	1.48	1.70	1.97	2.32	2.77	3.37	4.19
320	206.8	8.31	1.08	1.67	1.91	2.22	2.61	3.11	3.78	4.70
340	219.7	8.83	1.21	1.87	2.14	2.48	2.92	3.48	4.22	5.3
360	232.7	9.35	1.36	2.08	2.38	2.76	3.25	3.88	4.70	5.9
380	245.6	9.87	1.52	2.29	2.63	3.06	3.59	4.29	5.2	6.5

90-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
15	9.69	0.34	0.00	0.004	0.005	0.006	0.007	**0.008**	0.009	0.012
20	12.93	0.45	0.00	0.007	0.008	0.009	0.011	**0.013**	0.016	0.020
25	16.16	0.57	0.00	0.011	0.012	0.014	0.017	**0.020**	0.024	0.030
30	19.39	0.68	0.01	0.015	0.017	0.020	0.023	**0.028**	0.034	0.042
35	22.62	0.79	0.01	0.020	0.023	0.026	0.031	**0.037**	0.045	0.056
40	25.85	0.91	0.01	0.026	0.029	0.034	0.040	**0.048**	0.058	0.072
45	29.08	1.02	0.02	0.032	0.036	0.042	0.050	**0.059**	0.072	0.090
50	32.32	1.13	0.02	0.038	0.044	0.051	0.060	**0.072**	0.087	0.108
60	38.78	1.36	0.03	0.054	0.062	0.072	0.084	**0.101**	0.122	0.152
70	45.24	1.58	0.04	0.072	0.083	0.096	0.113	**0.134**	0.163	0.202
80	51.7	1.81	0.05	0.092	0.105	0.122	0.143	**0.171**	0.208	0.259
90	58.2	2.04	0.06	0.114	0.131	0.152	0.179	**0.213**	0.260	0.322
100	64.6	2.26	0.08	0.139	0.160	0.186	0.218	**0.260**	0.316	0.392
110	71.1	2.49	0.10	0.166	0.190	0.221	0.259	**0.309**	0.376	0.468
120	77.5	2.72	0.11	0.194	0.222	0.259	0.303	**0.361**	0.440	0.55
130	84.0	2.94	0.13	0.226	0.259	0.301	0.353	**0.421**	0.51	0.64
140	90.5	3.17	0.16	0.259	0.298	0.344	0.404	**0.481**	0.59	0.73
150	96.9	3.40	0.18	0.294	0.338	0.391	0.460	**0.55**	0.67	0.83
160	103.4	3.62	0.20	0.332	0.381	0.442	0.52	**0.62**	0.76	0.94
170	109.9	3.85	0.23	0.371	0.425	0.493	0.58	**0.69**	0.84	1.04
180	116.3	4.07	0.26	0.413	0.472	0.55	0.64	**0.77**	0.94	1.17
190	122.8	4.30	0.29	0.457	0.52	0.61	0.72	**0.85**	1.03	1.29
200	129.3	4.53	0.32	0.50	0.58	0.67	0.78	**0.94**	1.14	1.42
220	142.2	4.98	0.39	0.60	0.69	0.80	0.94	**1.12**	1.36	1.69
240	155.1	5.43	0.46	0.70	0.81	0.94	1.10	**1.31**	1.59	1.98
260	168.0	5.89	0.54	0.82	0.94	1.08	1.27	**1.52**	1.84	2.30
280	181.0	6.34	0.62	0.93	1.07	1.24	1.46	**1.74**	2.11	2.62
300	193.9	6.77	0.72	1.07	1.21	1.41	1.65	**1.97**	2.40	2.98
320	206.8	7.25	0.82	1.19	1.37	1.58	1.86	**2.22**	2.70	3.38
340	219.7	7.70	0.92	1.33	1.53	1.78	2.09	**2.49**	3.02	3.78
360	232.7	8.15	1.03	1.49	1.71	1.98	2.32	**2.78**	3.39	4.20
380	245.6	8.60	1.15	1.65	1.89	2.20	2.58	**3.08**	3.73	4.65
400	258.5	9.05	1.27	1.81	2.08	2.41	2.82	**3.38**	4.10	5.1
420	271.5	9.51	1.40	1.98	2.28	2.63	3.10	**3.70**	4.50	5.6
440	284.4	9.96	1.54	2.17	2.48	2.89	3.39	**4.02**	4.90	6.1

96-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per econd.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
15	9.69	0.30	0.00	0.003	0.003	0.004	0.005	**0.006**	0.007	0.009
20	12.93	0.40	0.00	0.005	0.006	0.007	0.008	**0.010**	0.012	0.015
30	19.39	0.60	0.01	0.011	0.013	0.015	0.017	**0.020**	0.025	0.031
40	25.85	0.80	0.01	0.019	0.021	0.025	0.029	**0.035**	0.042	0.053
50	32.32	0.99	0.02	0.028	0.032	0.037	0.043	**0.052**	0.063	0.078
60	38.78	1.19	0.02	0.039	0.045	0.052	0.061	**0.073**	0.089	0.110
70	45.24	1.39	0.03	0.052	0.060	0.070	0.082	**0.097**	0.118	0.147
80	51.7	1.59	0.04	0.067	0.077	0.089	0.104	**0.124**	0.152	0.188
90	58.2	1.79	0.05	0.083	0.095	0.111	0.130	**0.155**	0.188	0.234
100	64.6	1.99	0.06	0.101	0.116	0.135	0.158	**0.188**	0.229	0.286
110	71.1	2.19	0.07	0.121	0.138	0.161	0.188	**0.226**	0.273	0.341
120	77.5	2.39	0.09	0.143	0.163	0.190	0.222	**0.267**	0.322	0.401
130	84.0	2.59	0.10	0.165	0.189	0.220	0.259	**0.308**	0.374	0.466
140	90.5	2.79	0.12	0.189	0.218	0.251	0.297	**0.352**	0.429	0.54
150	96.9	2.99	0.14	0.216	0.248	0.288	0.338	**0.401**	0.489	0.61
160	103.4	3.19	0.16	0.242	0.279	0.322	0.380	**0.451**	0.55	0.68
170	109.9	3.39	0.18	0.271	0.311	0.361	0.425	**0.51**	0.62	0.76
180	116.3	3.59	0.20	0.302	0.348	0.402	0.471	**0.56**	0.68	0.86
190	122.8	3.78	0.22	0.332	0.381	0.442	0.52	**0.62**	0.85	0.94
200	129.3	3.98	0.25	0.366	0.420	0.488	0.57	**0.68**	0.83	1.03
220	142.2	4.38	0.30	0.437	0.50	0.58	0.68	**0.81**	0.99	1.23
240	155.1	4.77	0.36	0.52	0.59	0.68	0.80	**0.95**	1.17	1.45
260	168.0	5.17	0.42	0.60	0.68	0.79	0.93	**1.11**	1.34	1.68
280	181.0	5.57	0.48	0.68	0.78	0.91	1.07	**1.27**	1.55	1.93
300	193.9	5.97	0.55	0.78	0.89	1.03	1.22	**1.45**	1.76	2.19
320	206.8	6.37	0.63	0.87	1.00	1.16	1.36	**1.63**	1.98	2.46
340	219.7	6.76	0.71	0.98	1.12	1.30	1.53	**1.82**	2.22	2.76
360	232.7	7.16	0.80	1.08	1.25	1.44	1.70	**2.02**	2.47	3.07
380	245.6	7.56	0.89	1.20	1.38	1.60	1.88	**2.24**	2.72	3.39
400	258.5	7.96	0.98	1.32	1.52	1.76	2.07	**2.48**	3.00	3.73
420	271.5	8.36	1.09	1.44	1.66	1.92	2.27	**2.69**	3.28	4.08
440	284.4	8.75	1.19	1.58	1.81	2.10	2.47	**2.93**	3.58	4.45
460	297.3	9.15	1.30	1.71	1.96	2.28	2.68	**3.19**	3.88	4.82
480	310.2	9.55	1.42	1.86	2.13	2.48	2.90	**3.46**	4.21	5.2
500	323.2	9.95	1.54	2.00	2.29	2.66	3.12	**3.72**	4.52	5.6

102-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
20	12.93	0.35	0.00	0.004	0.004	0.005	0.006	**0.007**	0.009	0.011
30	19.39	0.53	0.00	0.008	0.009	0.011	0.013	**0.015**	0.018	0.023
40	25.85	0.70	0.01	0.014	0.016	0.018	0.022	**0.026**	0.031	0.039
50	32.32	0.88	0.01	0.021	0.024	0.028	0.033	**0.039**	0.047	0.059
60	38.78	1.06	0.02	0.029	0.034	0.039	0.046	**0.055**	0.066	0.082
70	45.24	1.23	0.02	0.039	0.045	0.052	0.061	**0.073**	0.088	0.110
80	51.7	1.41	0.03	0.050	0.057	0.066	0.078	**0.093**	0.113	0.141
90	58.2	1.59	0.04	0.062	0.071	0.083	0.097	**0.116**	0.141	0.175
100	64.6	1.76	0.05	0.076	0.086	0.101	0.118	**0.141**	0.171	0.212
110	71.1	1.94	0.06	0.090	0.103	0.119	0.141	**0.167**	0.204	0.253
120	77.5	2.11	0.07	0.106	0.122	0.141	0.165	**0.197**	0.239	0.298
130	84.0	2.29	0.08	0.123	0.141	0.163	0.192	**0.228**	0.278	0.345
140	90.5	2.47	0.09	0.141	0.162	0.187	0.220	**0.262**	0.319	0.398
150	96.9	2.64	0.11	0.159	0.182	0.212	0.249	**0.298**	0.361	0.450
160	103.4	2.82	0.12	0.180	0.207	0.239	0.281	**0.335**	0.408	0.51
170	109.9	3.00	0.14	0.201	0.231	0.268	0.315	**0.375**	0.456	0.57
180	116.3	3.17	0.16	0.224	0.258	0.299	0.350	**0.417**	0.51	0.63
190	122.8	3.35	0.17	0.248	0.283	0.330	0.388	**0.461**	0.56	0.70
200	129.3	3.52	0.19	0.272	0.311	0.361	0.424	**0.51**	0.62	0.77
220	142.2	3.88	0.23	0.323	0.371	0.431	0.51	**0.60**	0.74	0.92
240	155.1	4.23	0.28	0.381	0.438	0.51	0.60	**0.71**	0.86	1.07
260	168.0	4.58	0.33	0.441	0.51	0.59	0.69	**0.82**	1.00	1.25
280	181.0	4.93	0.38	0.51	0.58	0.68	0.79	**0.94**	1.14	1.43
300	193.9	5.29	0.44	0.58	0.66	0.77	0.90	**1.08**	1.31	1.63
320	206.8	5.64	0.49	0.65	0.74	0.86	1.02	**1.22**	1.47	1.83
340	219.7	5.99	0.56	0.73	0.84	0.97	1.13	**1.36**	1.65	2.05
360	232.7	6.34	0.62	0.81	0.93	1.07	1.27	**1.51**	1.83	2.28
380	245.6	6.70	0.70	0.89	1.03	1.18	1.39	**1.67**	2.02	2.52
400	258.5	7.05	0.77	0.98	1.13	1.31	1.53	**1.83**	2.23	2.77
420	271.5	7.40	0.85	1.08	1.23	1.43	1.68	**2.00**	2.44	3.02
440	284.4	7.75	0.93	1.17	1.34	1.56	1.83	**2.19**	2.67	3.30
460	297.3	8.10	1.02	1.27	1.46	1.69	1.98	**2.38**	2.89	3.59
480	310.2	8.46	1.11	1.38	1.58	1.83	2.16	**2.58**	3.12	3.89
500	323.2	8.81	1.20	1.48	1.71	1.98	2.32	**2.78**	3.38	4.20
550	355.5	9.69	1.46	1.77	2.02	2.36	2.76	**3.30**	4.01	4.99

108-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
20	12.93	0.31	0.00	0.003	0.004	0.004	0.005	**0.006**	0.008	0.009
30	19.39	0.47	0.00	0.006	0.007	0.008	0.010	**0.011**	0.014	0.017
40	25.85	0.63	0.01	0.010	0.012	0.014	0.016	**0.019**	0.024	0.029
50	32.32	0.79	0.01	0.016	0.018	0.021	0.025	**0.029**	0.036	0.045
60	38.78	0.94	0.01	0.022	0.025	0.029	0.035	**0.041**	0.050	0.062
70	45.24	1.10	0.02	0.029	0.034	0.039	0.046	**0.055**	0.067	0.083
80	51.7	1.26	0.02	0.038	0.043	0.050	0.059	**0.070**	0.086	0.107
90	58.2	1.41	0.03	0.047	0.054	0.062	0.073	**0.087**	0.106	0.132
100	64.6	1.57	0.04	0.057	0.066	0.076	0.089	**0.106**	0.128	0.161
110	71.1	1.73	0.05	0.068	0.078	0.090	0.106	**0.126**	0.153	0.191
120	77.5	1.89	0.06	0.080	0.092	0.106	0.124	**0.148**	0.181	0.225
130	84.0	2.04	0.07	0.092	0.106	0.123	0.144	**0.172**	0.209	0.261
140	90.5	2.20	0.08	0.107	0.122	0.141	0.166	**0.198**	0.240	0.299
150	96.9	2.36	0.09	0.122	0.138	0.161	0.188	**0.225**	0.273	0.340
160	103.4	2.52	0.10	0.136	0.156	0.181	0.212	**0.252**	0.309	0.382
180	116.3	2.83	0.12	0.169	0.194	0.225	0.264	**0.314**	0.382	0.477
200	129.3	3.14	0.15	0.206	0.237	0.272	0.321	**0.382**	0.466	0.58
220	142.2	3.46	0.19	0.246	0.281	0.326	0.382	**0.457**	0.56	0.70
240	155.1	3.77	0.22	0.289	0.330	0.382	0.450	**0.54**	0.65	0.81
260	168.0	4.09	0.26	0.335	0.384	0.445	0.52	**0.62**	0.76	0.94
280	181.0	4.40	0.30	0.382	0.440	0.51	0.60	**0.72**	0.87	1.08
300	193.9	4.72	0.35	0.436	0.50	0.58	0.68	**0.81**	0.99	1.23
320	206.8	5.03	0.39	0.491	0.56	0.66	0.77	**0.92**	1.12	1.38
340	219.7	5.34	0.44	0.55	0.63	0.73	0.86	**1.03**	1.24	1.55
360	232.7	5.66	0.50	0.61	0.70	0.81	0.96	**1.14**	1.38	1.72
380	245.6	5.97	0.55	0.68	0.78	0.90	1.06	**1.26**	1.53	1.90
400	258.5	6.29	0.61	0.74	0.85	0.99	1.16	**1.38**	1.68	2.09
420	271.5	6.60	0.68	0.81	0.93	1.08	1.27	**1.51**	1.84	2.29
440	284.4	6.92	0.74	0.88	1.02	1.18	1.38	**1.65**	2.00	2.49
460	297.3	7.23	0.81	0.96	1.11	1.28	1.50	**1.78**	2.18	2.71
480	310.2	7.55	0.88	1.04	1.19	1.38	1.63	**1.94**	2.36	2.93
500	323.2	7.86	0.96	1.12	1.28	1.49	1.75	**2.09**	2.54	3.17
550	355.5	8.65	1.16	1.34	1.54	1.78	2.09	**2.50**	3.03	3.79
600	387.8	9.43	1.38	1.57	1.81	2.09	2.47	**2.93**	3.58	4.42
650	420.1	10.22	1.62	1.82	2.09	2.42	2.85	**3.40**	4.12	5.20

114-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
30	19.39	0.42	0.00	0.004	0.005	0.006	0.007	**0.009**	0.011	0.013
40	25.85	0.56	0.00	0.008	0.009	0.011	0.013	**0.015**	0.018	0.023
50	32.32	0.71	0.01	0.012	0.014	0.016	0.019	**0.023**	0.028	0.034
60	38.78	0.85	0.01	0.017	0.019	0.023	0.027	**0.032**	0.038	0.048
70	45.24	0.99	0.02	0.023	0.026	0.030	0.035	**0.042**	0.051	0.064
80	51.7	1.13	0.02	0.029	0.033	0.038	0.045	**0.054**	0.066	0.082
90	58.2	1.27	0.03	0.036	0.041	0.048	0.056	**0.067**	0.082	0.102
100	64.6	1.41	0.03	0.044	0.050	0.059	0.068	**0.082**	0.099	0.123
110	71.1	1.55	0.04	0.052	0.060	0.069	0.082	**0.097**	0.118	0.147
120	77.5	1.69	0.04	0.061	0.070	0.082	0.096	**0.114**	0.138	0.173
130	84.0	1.83	0.05	0.071	0.081	0.094	0.112	**0.132**	0.161	0.200
140	90.5	1.98	0.06	0.081	0.094	0.108	0.127	**0.152**	0.185	0.230
150	96.9	2.12	0.07	0.093	0.106	0.123	0.145	**0.173**	0.210	0.261
160	103.4	2.26	0.08	0.104	0.120	0.139	0.163	**0.195**	0.237	0.294
180	116.3	2.54	0.10	0.130	0.149	0.173	0.202	**0.242**	0.295	0.367
200	129.3	2.82	0.12	0.158	0.181	0.210	0.248	**0.294**	0.358	0.446
220	142.2	3.10	0.15	0.188	0.217	0.251	0.294	**0.351**	0.428	0.53
240	155.1	3.38	0.18	0.221	0.253	0.294	0.347	**0.412**	0.50	0.62
260	168.0	3.67	0.21	0.257	0.294	0.341	0.401	**0.479**	0.58	0.72
280	181.0	3.95	0.24	0.294	0.338	0.391	0.460	**0.55**	0.67	0.83
300	193.9	4.23	0.28	0.333	0.382	0.445	0.52	**0.62**	0.76	0.94
320	206.8	4.52	0.32	0.377	0.432	0.50	0.59	**0.70**	0.86	1.07
340	219.7	4.80	0.36	0.421	0.482	0.56	0.66	**0.79**	0.96	1.19
360	232.7	5.08	0.40	0.469	0.54	0.63	0.73	**0.88**	1.07	1.32
380	245.6	5.36	0.45	0.52	0.60	0.69	0.81	**0.97**	1.17	1.46
400	258.5	5.64	0.50	0.57	0.65	0.76	0.89	**1.07**	1.29	1.61
420	271.5	5.93	0.55	0.62	0.72	0.83	0.98	**1.17**	1.42	1.76
440	284.4	6.21	0.60	0.68	0.78	0.90	1.07	**1.27**	1.54	1.92
460	297.3	6.49	0.65	0.74	0.85	0.98	1.16	**1.38**	1.67	2.08
480	310.2	6.77	0.71	0.80	0.92	1.07	1.25	**1.48**	1.82	2.26
500	323.2	7.06	0.77	0.86	0.99	1.14	1.34	**1.61**	1.95	2.43
550	355.5	7.76	0.94	1.03	1.18	1.37	1.61	**1.92**	2.33	2.90
600	387.8	8.47	1.11	1.21	1.38	1.61	1.88	**2.25**	2.74	3.40
650	420.1	9.17	1.31	1.40	1.61	1.87	2.19	**2.61**	3.18	3.96
700	452.4	9.88	1.52	1.61	1.84	2.14	2.51	**2.99**	3.64	4.52

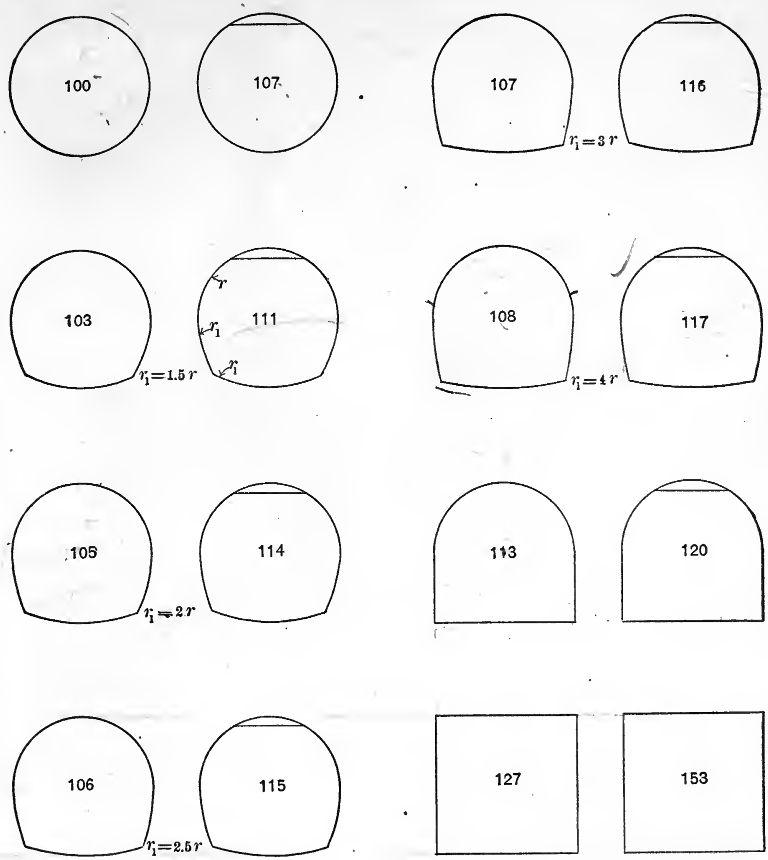
Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
30	19.39	0.38	0.00	0.004	0.004	0.005	0.006	**0.007**	0.008	0.010
40	25.85	0.51	0.00	0.006	0.007	0.008	0.010	**0.012**	0.014	0.018
50	32.32	0.64	0.01	0.009	0.011	0.013	0.015	**0.018**	0.021	0.027
60	38.78	0.76	0.01	0.013	0.015	0.018	0.021	**0.025**	0.030	0.037
70	45.24	0.89	0.01	0.018	0.020	0.023	0.027	**0.033**	0.040	0.050
80	51.7	1.02	0.02	0.022	0.026	0.030	0.035	**0.042**	0.051	0.063
90	58.2	1.15	0.02	0.028	0.032	0.037	0.044	**0.052**	0.064	0.079
100	64.6	1.27	0.03	0.034	0.039	0.045	0.053	**0.063**	0.077	0.096
110	71.1	1.40	0.03	0.041	0.047	0.054	0.064	**0.076**	0.092	0.114
120	77.5	1.53	0.04	0.048	0.055	0.064	0.075	**0.089**	0.108	0.134
140	90.5	1.78	0.05	0.064	0.073	0.085	0.100	**0.118**	0.144	0.179
160	103.4	2.04	0.06	0.082	0.094	0.108	0.127	**0.152**	0.184	0.229
180	116.3	2.29	0.08	0.102	0.116	0.134	0.158	**0.188**	0.229	0.284
200	129.3	2.55	0.10	0.123	0.141	0.163	0.192	**0.229**	0.279	0.348
220	142.2	2.80	0.12	0.147	0.168	0.195	0.229	**0.273**	0.332	0.413
240	155.1	3.06	0.15	0.172	0.197	0.229	0.269	**0.321**	0.390	0.485
260	168.0	3.31	0.17	0.200	0.229	0.267	0.312	**0.372**	0.452	0.56
280	181.0	3.56	0.20	0.228	0.263	0.305	0.359	**0.428**	0.52	0.65
300	193.9	3.82	0.23	0.260	0.298	0.347	0.407	**0.484**	0.59	0.74
320	206.8	4.07	0.26	0.293	0.337	0.390	0.459	**0.55**	0.66	0.83
340	219.7	4.33	0.29	0.328	0.377	0.438	0.51	**0.61**	0.74	0.92
360	232.7	4.58	0.33	0.364	0.418	0.485	0.57	**0.68**	0.82	1.03
380	245.6	4.84	0.36	0.402	0.462	0.54	0.63	**0.75**	0.92	1.14
400	258.5	5.09	0.40	0.442	0.51	0.59	0.69	**0.82**	1.00	1.25
420	271.5	5.35	0.44	0.484	0.56	0.64	0.76	**0.90**	1.10	1.37
440	284.4	5.60	0.49	0.53	0.61	0.70	0.83	**0.98**	1.19	1.49
460	297.3	5.86	0.53	0.57	0.66	0.76	0.90	**1.07**	1.30	1.62
480	310.2	6.11	0.58	0.62	0.71	0.83	0.97	**1.16**	1.42	1.76
500	323.2	6.37	0.63	0.67	0.77	0.90	1.04	**1.25**	1.52	1.88
550	355.5	7.00	0.76	0.80	0.92	1.07	1.25	**1.48**	1.82	2.26
600	387.8	7.64	0.91	0.94	1.08	1.25	1.47	**1.75**	2.13	2.65
650	420.1	8.27	1.06	1.08	1.25	1.45	1.71	**2.04**	2.48	3.07
700	452.4	8.91	1.23	1.25	1.43	1.67	1.96	**2.33**	2.83	3.52
750	484.7	9.55	1.42	1.42	1.63	1.88	2.22	**2.64**	3.22	4.00
800	517	10.18	1.61	1.59	1.83	2.12	2.49	**2.98**	3.62	4.50

132-INCH PIPE.

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
30	19.39	0.32	0.00	0.002	0.003	0.003	0.004	**0.004**	0.005	0.006
40	25.85	0.42	0.00	0.004	0.005	0.005	0.006	**0.007**	0.009	0.011
50	32.32	0.53	0.00	0.006	0.007	0.008	0.009	**0.011**	0.013	0.017
60	38.78	0.63	0.01	0.009	0.010	0.011	0.013	**0.016**	0.019	0.024
80	51.7	0.84	0.01	0.014	0.016	0.019	0.022	**0.026**	0.032	0.040
100	64.6	1.05	0.02	0.021	0.025	0.028	0.034	**0.040**	0.048	0.060
120	77.5	1.26	0.02	0.030	0.035	0.040	0.047	**0.056**	0.068	0.085
140	90.5	1.47	0.03	0.040	0.046	0.054	0.063	**0.075**	0.091	0.113
160	103.4	1.68	0.04	0.052	0.059	0.068	0.080	**0.096**	0.117	0.145
180	116.3	1.89	0.06	0.064	0.073	0.085	0.100	**0.119**	0.144	0.180
200	129.3	2.10	0.07	0.078	0.089	0.103	0.122	**0.144**	0.176	0.218
220	142.2	2.31	0.08	0.092	0.107	0.123	0.144	**0.172**	0.208	0.260
240	155.1	2.52	0.10	0.108	0.124	0.144	0.169	**0.202**	0.246	0.307
260	168.0	2.74	0.12	0.126	0.144	0.167	0.196	**0.234**	0.285	0.354
280	181.0	2.95	0.13	0.144	0.166	0.192	0.226	**0.268**	0.327	0.407
300	193.9	3.16	0.15	0.164	0.188	0.219	0.257	**0.305**	0.371	0.462
320	206.8	3.37	0.18	0.184	0.211	0.246	0.289	**0.344**	0.419	0.52
340	219.7	3.58	0.20	0.207	0.238	0.276	0.322	**0.386**	0.469	0.58
360	232.7	3.79	0.22	0.230	0.262	0.306	0.359	**0.429**	0.52	0.65
380	245.6	4.00	0.25	0.254	0.291	0.339	0.398	**0.472**	0.58	0.72
400	258.5	4.20	0.27	0.279	0.320	0.372	0.437	**0.52**	0.63	0.79
420	271.5	4.42	0.30	0.306	0.351	0.407	0.478	**0.57**	0.69	0.86
440	284.4	4.62	0.33	0.332	0.382	0.442	0.52	**0.62**	0.76	0.94
460	297.3	4.84	0.36	0.361	0.415	0.481	0.56	**0.68**	0.82	1.02
480	310.2	5.05	0.40	0.391	0.449	0.52	0.61	**0.73**	0.89	1.11
500	323.2	5.26	0.43	0.421	0.483	0.56	0.66	**0.79**	0.96	1.18
550	355.5	5.79	0.52	0.50	0.58	0.67	0.79	**0.94**	1.14	1.42
600	387.8	6.30	0.62	0.59	0.68	0.78	0.92	**1.11**	1.34	1.67
650	420.1	6.84	0.73	0.68	0.78	0.92	1.07	**1.28**	1.56	1.93
700	452.4	7.36	0.84	0.79	0.90	1.05	1.23	**1.47**	1.78	2.22
750	484.7	7.89	0.97	0.90	1.03	1.18	1.39	**1.67**	2.03	2.52
800	517	8.42	1.10	1.01	1.16	1.34	1.58	**1.88**	2.29	2.84
850	549	8.94	1.24	1.13	1.29	1.50	1.77	**2.10**	2.56	3.19
900	582	9.47	1.39	1.26	1.44	1.67	1.96	**2.33**	2.84	3.54
950	614	9.99	1.55	1.38	1.59	1.84	2.17	**2.59**	3.13	3.90

Discharge in		Velocity in Feet per Second.	Velocity Head, Feet.	Loss of Head in Feet per 1000 feet of length.						
Cubic Feet per Second.	Million Gallons per 24 Hours.			Extremely Smooth and Straight $c=140$	Very Smooth $c=130$	Good Masonry Aqueducts. $c=120$	Riveted Steel Pipe, New. $c=110$	Steel Pipe 10 Years Old, Brick Sewers. $c=100$	Rough. $c=90$	Very Rough. $c=80$
40	25.85	0.35	0.00	0.003	0.003	0.003	0.004	**0.005**	0.006	0.007
60	38.78	0.53	0.00	0.005	0.006	0.007	0.009	**0.010**	0.012	0.015
80	51.7	0.71	0.01	0.009	0.011	0.012	0.014	**0.017**	0.021	0.026
100	64.6	0.88	0.01	0.014	0.016	0.019	0.022	**0.026**	0.032	0.040
120	77.5	1.06	0.02	0.020	0.023	0.026	0.031	**0.037**	0.045	0.055
140	90.5	1.24	0.02	0.026	0.030	0.035	0.041	**0.049**	0.059	0.074
160	103.4	1.41	0.03	0.034	0.039	0.045	0.052	**0.062**	0.076	0.094
180	116.3	1.59	0.04	0.042	0.048	0.056	0.065	**0.078**	0.094	0.117
200	129.3	1.77	0.05	0.050	0.058	0.068	0.079	**0.094**	0.115	0.143
220	142.2	1.94	0.06	0.060	0.070	0.080	0.094	**0.113**	0.137	0.171
240	155.1	2.12	0.07	0.071	0.082	0.094	0.111	**0.132**	0.161	0.200
260	168.0	2.30	0.08	0.082	0.094	0.109	0.128	**0.153**	0.186	0.232
280	181.0	2.48	0.09	0.094	0.108	0.126	0.148	**0.176**	0.213	0.267
300	193.9	2.65	0.11	0.107	0.123	0.143	0.168	**0.200**	0.242	0.302
320	206.8	2.83	0.12	0.121	0.139	0.161	0.188	**0.226**	0.273	0.341
340	219.7	3.01	0.14	0.136	0.156	0.181	0.211	**0.252**	0.307	0.381
360	232.7	3.18	0.16	0.151	0.173	0.200	0.235	**0.281**	0.341	0.424
380	245.6	3.36	0.18	0.167	0.191	0.222	0.260	**0.309**	0.377	0.469
400	258.5	3.54	0.19	0.183	0.209	0.243	0.287	**0.341**	0.414	0.52
420	271.5	3.71	0.21	0.201	0.230	0.267	0.313	**0.373**	0.455	0.57
440	284.4	3.89	0.23	0.218	0.249	0.290	0.341	**0.406**	0.494	0.62
460	297.3	4.07	0.26	0.237	0.272	0.314	0.371	**0.441**	0.54	0.67
480	310.2	4.24	0.28	0.256	0.293	0.341	0.400	**0.477**	0.58	0.72
500	323.2	4.42	0.30	0.277	0.318	0.369	0.432	**0.52**	0.63	0.78
550	355.5	4.86	0.37	0.330	0.379	0.439	0.52	**0.62**	0.75	0.93
600	387.8	5.30	0.44	0.388	0.448	0.52	0.61	**0.72**	0.88	1.08
650	420.1	5.75	0.51	0.450	0.52	0.60	0.70	**0.84**	1.02	1.27
700	452.4	6.19	0.59	0.52	0.59	0.68	0.80	**0.96**	1.17	1.46
750	484.7	6.63	0.68	0.58	0.67	0.78	0.92	**1.09**	1.33	1.66
800	517	7.07	0.78	0.66	0.76	0.88	1.03	**1.23**	1.49	1.86
850	549	7.51	0.88	0.74	0.85	0.98	1.16	**1.38**	1.67	2.08
900	582	7.96	0.98	0.82	0.94	1.09	1.28	**1.53**	1.86	2.32
950	614	8.40	1.09	0.91	1.04	1.21	1.42	**1.69**	2.06	2.57
1000	646	8.84	1.21	1.00	1.14	1.33	1.56	**1.86**	2.27	2.82
1100	711	9.72	1.46	1.19	1.37	1.58	1.86	**2.22**	2.70	3.37

RELATIVE DISCHARGING CAPACITIES OF AQUEDUCTS.



	Relative Elements of Conduits when Flowing Full.				At Approximate Point of Maximum Discharge.			
	Area.	Wetted Perimeter.	Mean Hydraulic Radius.	Velocity.	Area.	Wetted Perimeter.	Mean Hydraulic Radius.	Velocity.
Circle	1000	1000	1000	1000	975	841	1160	1098
$r_1=1.5r$	1034	1023	1011	1007	1009	864	1168	1103
$r_1=2.0r$	1057	1040	1018	1011	1032	881	1172	1106
$r_1=2.5r$	1071	1054	1018	1011	1046	895	1169	1104
$r_1=3r$	1078	1063	1016	1010	1053	904	1165	1101
$r_1=4r$	1089	1076	1014	1009	1064	917	1160	1098
½ square	1136	1136	1000	1000	1111	977	1137	1083
Square	1273	1273	1000	1000	1273	955	1333	1199

345 .- 300 =
115

$c = 125$. At point of maximum discharge the quantity is taken as 12% greater than in a circular aqueduct of the same height and width running full.

Slope in Feet per 1000.	Slope in Feet per Mile.	8′	9′	10′	11′	12′	13′	14′
		Discharge in Million Gallons Daily.						
0.030	0.158	34	46	60	78	98	120	146
0.035	0.185	36	50	66	84	106	130	159
0.040	0.211	39	53	71	91	114	140	171
0.045	0.238	42	57	75	97	121	150	182
0.050	0.264	44	60	79	102	128	158	192
0.055	0.290	46	63	84	108	135	167	203
0.060	0.317	49	66	88	112	142	175	212
0.065	0.343	51	69	91	118	148	182	221
0.070	0.370	53	72	95	122	154	190	231
0.080	0.422	57	78	102	132	166	205	248
0.090	0.475	61	83	109	140	176	218	265
0.10	0.528	64	88	116	148	186	230	280
0.11	0.581	68	92	122	156	196	242	295
0.12	0.634	71	97	127	164	205	254	309
0.14	0.739	77	105	138	178	224	276	336
0.16	0.845	83	113	149	192	240	297	361
0.18	0.950	88	120	159	204	256	316	385
0.20	1.056	93	127	168	215	271	335	407
0.22	1.162	98	134	177	227	285	352	428
0.24	1.267	103	140	185	239	300	370	450
0.26	1.373	108	147	194	249	313	386	469
0.28	1.478	112	153	201	259	325	402	488
0.30	1.584	116	159	209	269	338	418	508
0.35	1.848	126	172	227	291	366	453	550
0.40	2.112	136	185	244	314	395	487	591
0.45	2.376	145	197	260	335	420	519	631
0.50	2.640	153	209	275	354	445	549	668
0.55	2.904	162	219	290	373	468	579	701
0.60	3.168	169	230	304	390	490	606	736
0.65	3.432	177	240	317	407	511	631	770
0.70	3.696	184	250	330	424	533	659	800
0.80	4.224	197	269	355	456	573	709	860
0.90	4.752	210	287	378	485	610	754	918
1.00	5.28	223	304	400	514	647	800	970
1.10	5.81	235	319	421	541	680	840	1020

AQUEDUCTS,—15 TO 21 FEET.

$c = 125$. At point of maximum discharge the quantity is taken as 12% greater than in a circular aqueduct of the same height and width running full.

Slope in Feet per 1000.	Slope in Feet per Mile.	15′	16′	17′	18′	19′	20′	21′
		Discharge in Million Gallons Daily.						
0.020	0.106	140	167	196	228	263	300	341
0.022	0.116	148	176	205	239	276	316	358
0.024	0.127	155	184	215	250	289	330	376
0.026	0.137	162	192	227	261	303	346	392
0.028	0.148	169	200	237	274	315	360	410
0.030	0.158	176	208	245	285	326	374	426
0.035	0.185	190	226	266	310	355	406	460
0.040	0.211	205	243	286	330	381	437	495
0.045	0.238	218	258	305	352	406	465	528
0.050	0.264	232	274	323	372	430	493	560
0.055	0.290	243	288	340	395	453	518	588
0.060	0.317	254	300	353	410	475	542	617
0.065	0.343	266	315	372	433	495	569	642
0.070	0.370	277	328	388	450	516	591	670
0.080	0.422	298	353	410	480	552	635	720
0.09	0.475	317	376	440	510	591	670	770
0.10	0.528	336	398	470	542	625	718	810
0.11	0.581	354	420	490	570	660	750	860
0.12	0.634	370	439	510	600	690	790	900
0.14	0.739	404	477	562	650	750	860	980
0.16	0.845	432	512	600	700	810	920	1050
0.18	0.950	461	547	640	740	860	980	1120
0.20	1.056	488	579	680	790	910	1040	1180
0.22	1.162	513	610	710	830	960	1100	1240
0.24	1.267	540	640	750	870	1000	1150	1300
0.26	1.373	562	668	780	910	1050	1200	1360
0.28	1.478	585	694	810	940	1090	1250	1420
0.30	1.584	608	720	840	980	1130	1300	1470
0.35	1.848	660	780	915	1060	1230	1410	1600
0.40	2.112	710	841	990	1140	1320	1520	1720
0.45	2.376	758	896	1050	1220	1410	1620	1830
0.50	2.640	800	950	1110	1290	1490	1700	1940
0.55	2.904	842	1000	1170	1360	1570	1800	2040
0.60	3.168	885	1040	1230	1420	1650	1880	2130
0.65	3.432	921	1090	1280	1480	1720	1960	2230

SEWERS.

TABLE OF SLOPES REQUIRED TO PRODUCE GIVEN VELOCITIES.

Tile, $c=110$. Brick, $c=100$.

Size.	Cubic Feet per Second. $v=1$	$v=2$	$v=2.5$	$v=3$	$v=4$	$v=5$	$v=7$	$v=10$
		Slope in Feet per 1000.						
4″ Tile	0.087	6.5	9.8	13.8	23.5	35.5	66.0	128
5″ ″	0.136	5.0	7.6	10.6	18.1	27.3	51.0	99
6″ ″	0.196	4.05	6.1	8.6	14.6	22.0	41.1	80
8″ ″	0.349	2.90	4.39	6.2	10.5	15.8	29.5	57
10″ ″	0.545	2.24	3.39	4.74	8.1	12.2	22.8	44
12″ ″	0.785	1.80	2.73	3.82	6.5	9.8	18.4	35.6
15″ ″	1.23	1.39	2.10	2.95	5.0	7.6	14.2	27.5
18″ ″	1.77	1.13	1.70	2.38	4.06	6.1	11.5	22.2
21″ ″	2.41	0.94	1.42	1.99	3.40	5.1	9.6	18.5
24″ ″	3.14	0.80	1.22	1.71	2.90	4.39	8.2	15.9
27″ ″	3.98	0.70	1.06	1.49	2.52	3.82	7.1	13.8
30″ ″	4.91	0.62	0.94	1.31	2.24	3.39	6.3	12.2
30″ Brick	4.91	0.74	1.12	1.56	2.68	4.04	7.5	14.6
36″ ″	7.07	0.60	0.90	1.26	2.16	3.27	6.1	11.8
42″ ″	9.62	0.50	0.76	1.06	1.80	2.72	5.1	9.8
48″ ″	12.57	0.428	0.64	0.91	1.54	2.33	4.34	8.4
54″ ″	15.9	0.372	0.56	0.79	1.34	2.03	3.79	7.4
60″ ″	19.6	0.330	0.50	0.70	1.19	1.80	3.35	6.5
66″ ″	23.8	0.295	0.445	0.62	1.06	1.61	3.00	5.8
72″ ″	28.3	0.267	0.402	0.56	0.96	1.45	2.71	5.3
78″ ″	33.2	0.242	0.367	0.52	0.88	1.32	2.47	4.78
84″ ″	38.5	0.222	0.336	0.471	0.80	1.21	2.26	4.39
90″ ″	44.2	0.205	0.310	0.434	0.74	1.12	2.09	4.04
96″ ″	50.3	0.190	0.288	0.403	0.69	1.04	1.94	3.75
108″ ″	63.6	0.166	0.251	0.372	0.60	0.90	1.69	3.28
10′ ″	78.5	0.147	0.221	0.311	0.53	0.80	1.49	2.90
11′ ″	95.0	0.131	0.199	0.278	0.472	0.72	1.33	2.59
12′ ″	113	0.119	0.179	0.251	0.428	0.65	1.21	2.34
13′ ″	133	0.108	0.163	0.229	0.390	0.59	1.10	2.13
14′ ″	154	0.099	0.150	0.210	0.358	0.54	1.01	1.95
15′ ″	177	0.091	0.138	0.194	0.330	0.50	0.93	1.80
16′ ″	201	0.085	0.128	0.180	0.306	0.462	0.86	1.67
17′ ″	227	0.079	0.119	0.167	0.285	0.430	0.80	1.55
18′ ″	254	0.074	0.111	0.156	0.266	0.403	0.75	1.45
20′ ″	314	0.065	0.099	0.138	0.236	0.356	0.66	1.29

TILE SEWERS,—4 TO 12 INCHES.

$c = 110.$

Slope in Feet per 1000.	4″	5″	6″	8″	10″	12″
	Discharge in Cubic Feet per Second, Running Full.					
1.8	....	....	....	....	....	*1.57*
2.0	....	....	....	....	....	*1.66*
2.2	....	....	....	....	....	*1.75*
2.4	....	....	....	....	*1.13*	*1.83*
2.6	....	....	....	....	*1.18*	*1.91*
2.8	....	....	....	....	*1.23*	*1.99*
3.0	....	....	....	*0.71*	*1.28*	*2.06*
3.5	....	....	....	*0.77*	*1.39*	*2.24*
4.0	....	....	*0.39*	*0.83*	*1.49*	2.41
4.5	....	....	*0.41*	*0.88*	*1.59*	2.56
5	....	*0.27*	*0.44*	*0.94*	1.68	2.72
6	....	*0.30*	*0.48*	*1.03*	1.86	3.00
7	*0.18*	*0.33*	*0.53*	1.12	2.02	3.26
8	*0.19*	*0.35*	*0.57*	1.20	2.17	3.50
9	*0.21*	*0.37*	0.60	1.28	2.31	3.74
10	*0.22*	*0.40*	0.64	1.36	2.45	3.95
12	*0.24*	0.44	0.71	1.50	2.70	4.36
14	0.26	0.47	0.77	1.63	2.94	4.75
16	0.28	0.51	0.82	1.76	3.15	5.1
18	0.30	0.54	0.88	1.87	3.36	5.4
20	0.32	0.58	0.93	1.98	3.56	5.8
22	0.34	0.60	0.98	2.09	3.75	6.1
24	0.35	0.64	1.03	2.19	3.94	6.4
26	0.37	0.66	1.07	2.28	4.10	6.6
28	0.38	0.69	1.11	2.38	4.28	6.9
30	0.40	0.72	1.15	2.46	4.43	7.2
35	0.43	0.78	1.26	2.68	4.83	7.8
40	0.46	0.84	1.35	2.88	5.2	*8.4*
45	0.49	0.89	1.44	3.07	*5.5*	*8.9*
50	0.52	0.94	1.52	3.25	*5.8*	*9.4*
60	0.58	1.04	1.68	*3.58*	*6.4*	*10.4*
70	0.63	1.13	1.83	*3.90*	*7.0*	*11.3*
80	0.67	1.21	1.96	*4.18*	*7.5*	*12.1*
90	0.72	1.30	*2.10*	*4.46*	*8.0*	*12.9*
100	0.76	*1.37*	*2.22*	*4.73*	*8.5*	*13.7*

Quantities corresponding to velocities between 2 and 3 and over 10 feet per second are in italics.

TILE SEWERS,—15 TO 36 INCHES.

$c = 110$.

Slope in Feet per 1000.	15″	18″	21″	24″	27″	30″	36″
	Discharge in Cubic Feet per Second, Running Full.						
0.5	....	....	....	....	....	....	*14.1*
0.6	....	....	....	....	....	....	*15.6*
0.7	....	....	....	....	*7.9*	*10.5*	*16.9*
0.8	....	....	....	*6.3*	*8.5*	*11.3*	*18.2*
0.9	....	....	....	*6.7*	*9.1*	*12.0*	*19.4*
1.0	....	....	*5.0*	*7.1*	*9.6*	*12.7*	*20.5*
1.2	....	*3.7*	*5.5*	*7.8*	*10.6*	*14.0*	22.6
1.4	*2.5*	*4.0*	*6.0*	*8.5*	*11.5*	15.2	24.6
1.6	*2.6*	*4.3*	*6.4*	*9.1*	12.4	16.4	26.5
1.8	*2.8*	*4.5*	*6.8*	9.7	13.2	17.4	28.2
2.0	*3.0*	*4.8*	7.2	10.3	14.0	18.4	29.8
2.2	*3.1*	*5.1*	7.6	10.8	14.7	19.4	31.4
2.4	*3.3*	5.3	8.0	11.4	15.4	20.4	32.9
2.6	*3.4*	5.5	8.3	11.8	16.1	21.2	34.4
2.8	*3.6*	5.8	8.7	12.3	16.8	22.1	35.7
3.0	3.7	6.0	9.0	12.8	17.4	23.0	37.1
3.5	4.0	6.5	9.8	13.9	18.9	25.0	40.3
4.0	4.3	7.0	10.5	14.9	20.4	26.9	43.4
4.5	4.6	7.5	11.2	15.9	21.6	28.6	46.2
5.0	4.9	7.9	11.9	16.8	23.0	30.3	48.9
6	5.4	8.7	13.1	18.6	25.4	33.4	54
7	5.9	9.5	14.2	20.2	27.5	36.4	59
8	6.3	10.2	15.3	21.7	29.6	39.0	63
9	6.7	10.9	16.3	23.1	31.5	41.6	67
10	7.1	11.5	17.2	24.5	33.4	44.0	*71*
12	7.8	12.7	19.0	27.0	36.8	48.6	*78*
14	8.5	13.8	20.6	29.4	*40.0*	*53*	*85*
16	9.1	14.8	22.2	*31.5*	*43.0*	*57*	*92*
18	9.7	15.8	23.6	*33.6*	*45.8*	*60*	*98*
20	10.3	16.7	*25.0*	*35.6*	*48.5*	*64*	*103*
22	10.9	17.6	*26.4*	*37.5*	*51*	*67*	*109*
24	11.4	*18.4*	*27.6*	*39.3*	*53*	*71*	*114*
26	11.9	*19.2*	*28.9*	*41.0*	*56*	*74*	*119*
28	*12.4*	*20.0*	*30.0*	*42.7*	*58*	*77*	*124*
30	*12.8*	*20.8*	*31.1*	*44.2*	*60*	*80*	*128*

Quantities corresponding to velocities between 2 and 3 and over 10 feet per second are in italics.

BRICK SEWERS,—30 TO 66 INCHES.

$c = 100.$

Slope in Feet per 1000.	30″	36″	42″	48″	54″	60″	66″
	Discharge in Cubic Feet per Second, Running Full.						
0.30	....	....	.....	...	...	...	*48*
0.35	....	....	.....	...	...	*41*	*52*
0.40	....	....	.....	...	*33*	*44*	*56*
0.45	....	....	.....	*26*	*35*	*46*	*60*
0.50	....	....	*19.3*	*27*	*37*	*49*	*63*
0.55	....	....	*20.3*	*29*	*39*	*52*	*67*
0.60	....	*14.2*	*21.2*	*30*	*41*	*54*	*70*
0.65	....	*14.8*	*22.2*	*32*	*43*	*57*	73
0.70	....	*15.4*	*23.1*	*33*	*45*	*59*	76
0.80	*10.2*	*16.6*	*24.8*	*35*	48	63	82
0.9	*10.9*	*17.6*	*26.5*	*38*	51	68	87
1.0	*11.6*	*18.7*	*28.0*	40	54	71	92
1.1	*12.2*	*19.7*	29.5	42	57	75	97
1.2	*12.8*	*20.6*	30.9	44	60	79	101
1.4	*13.9*	22.4	33.5	48	65	86	110
1.6	14.9	24.0	36.0	51	70	92	118
1.8	15.9	25.6	38.4	55	74	98	126
2.0	16.8	27.1	40.6	58	79	104	134
2.2	17.7	28.6	42.9	61	83	110	141
2.4	18.5	29.9	44.9	64	87	115	147
2.6	19.3	31.2	46.8	66	91	120	154
2.8	20.1	32.5	48.8	69	94	125	160
3.0	20.9	33.8	51	72	98	130	166
3.5	22.7	36.7	55	78	107	*141*	*181*
4.0	24.4	39.5	59	84	*114*	*151*	*194*
4.5	26.0	42.0	63	*90*	*122*	*161*	*207*
5.0	27.5	44.5	67	*95*	*129*	*170*	*219*
5.5	29.0	47	*70*	*100*	*136*	*180*	*231*
6.0	30.4	49	*74*	*105*	*143*	*188*	*241*
6.5	31.8	*51*	*77*	*109*	*149*	*197*	*253*
7	33.0	*53*	*80*	*114*	*155*	*205*	*263*
8	*35.5*	*57*	*86*	*122*	*166*	*220*	*282*
9	*37.8*	*61*	*92*	*130*	*178*	*234*	*301*
10	*40.0*	*65*	*97*	*138*	*188*	*248*	*319*
11	*42.1*	*68*	*102*	*145*	*198*	*261*	*335*

Quantities corresponding to velocities between 2 and 3 and over 7 feet per second are in italics.

BRICK SEWERS,—72 TO 108 INCHES.

$c=100$.

Slope in Feet per 1000.	72″	78″	84″	90″	96″	108″
	Discharge in Cubic Feet per Second, Running Full.					
0.18	....	....	....	....	....	*133*
0.20	....	....	....	....	*103*	*141*
0.22	....	....	*77*	*92*	*109*	*148*
0.24	....	*66*	*80*	*97*	*114*	*156*
0.26	....	*69*	*84*	*101*	*119*	*162*
0.28	*58*	*72*	*87*	*105*	*124*	*169*
0.30	*60*	*74*	*91*	*109*	*129*	*175*
0.32	*62*	*77*	*94*	*113*	*133*	*182*
0.34	*65*	*80*	*97*	*116*	*138*	*188*
0.36	*66*	*82*	*100*	*120*	*142*	194
0.38	*69*	*85*	*103*	*124*	*146*	199
0.40	*71*	*87*	*106*	*127*	*150*	205
0.45	*75*	*93*	*113*	136	160	218
0.50	*79*	*98*	119	144	169	230
0.55	*84*	103	126	151	178	243
0.60	88	108	132	158	187	255
0.65	92	113	138	166	196	266
0.70	95	118	143	172	203	277
0.75	99	122	149	179	211	288
0.8	102	126	154	185	218	298
0.9	109	135	164	197	233	316
1.0	116	143	173	207	246	335
1.1	122	150	182	220	259	353
1.2	128	158	192	230	272	370
1.3	133	164	200	240	284	386
1.4	139	171	208	250	295	402
1.5	144	178	216	260	306	418
1.6	149	184	224	269	317	433
1.8	159	196	238	287	338	*460*
2.0	168	207	252	304	*357*	*488*
2.2	176	218	265	*319*	*376*	*510*
2.4	185	229	*278*	*335*	*395*	*540*
2.6	194	*239*	*290*	*349*	*412*	*560*
2.8	*201*	*249*	*302*	*364*	*429*	*570*
3.0	*209*	*258*	*314*	*378*	*446*	*610*

Quantities corresponding to velocities between 2 and 3 and over 7 feet per second are in italics.

BRICK SEWERS,—10 TO 15 FEET.

$c = 100.$

Slope in Feet per 1000.	10′	11′	12′	13′	14′	15′
	Discharge in Cubic Feet per Second, Running Full.					
0.09	....	....	....	....	....	*350*
0.10	....	....	....	....	*310*	*372*
0.11	....	....	....	*268*	*326*	*391*
0.12	....	....	*228*	*281*	*341*	*410*
0.13	....	....	*238*	*294*	*356*	*428*
0.14	....	*197*	*248*	*305*	*371*	*445*
0.15	*159*	*205*	*257*	*318*	*385*	*462*
0.16	*165*	*211*	*266*	*329*	*400*	*479*
0.18	*176*	*225*	*284*	*350*	*425*	*510*
0.20	*186*	*239*	*300*	*370*	*450*	540
0.22	*196*	*251*	*316*	*390*	474	570
0.24	*205*	*263*	*331*	409	496	600
0.26	*214*	*275*	346	426	520	620
0.28	*222*	286	360	444	540	650
0.30	*231*	297	374	461	560	670
0.32	240	307	387	477	580	700
0.34	247	318	400	494	600	720
0.36	255	328	412	510	620	740
0.38	262	337	425	520	640	760
0.40	270	347	436	540	650	780
0.45	288	370	465	570	700	840
0.50	305	391	492	610	740	890
0.55	321	412	520	640	780	930
0.60	336	432	540	670	810	980
0.65	351	451	570	700	850	1020
0.70	365	470	590	730	890	1060
0.75	380	488	610	760	920	1100
0.8	392	500	630	780	950	1140
0.9	418	540	680	830	1010	1220
1.0	443	570	720	880	1070	*1290*
1.1	466	600	750	930	*1130*	*1360*
1.2	488	630	790	*980*	*1180*	*1420*
1.3	510	660	*820*	*1020*	*1240*	*1480*
1.4	530	*680*	*860*	*1060*	*1290*	*1540*
1.5	*550*	*710*	*890*	*1100*	*1340*	*1600*

Quantities corresponding to velocities between 2 and 3 and over 7 feet per second are in italics.

COMPUTATION OF DECREASE IN THE VALUE OF *c* IN CAST-IRON PIPE, WITH AVERAGE SOFT UNFILTERED RIVER WATER, THROUGH A PERIOD OF YEARS.

1st. Assume that the original value of *c* is 130.

2d. Assume that the increase in loss of head due to tuberculation, etc., amounts to 3% per year.

3d. Assume that the diameter of the pipe is reduced by tuberculation at the rate of 0.01 inch per year, and that the value of *c* must be modified to correct for this.

Age of Pipe in Years.	Value of *c*, with no Allowance for Reduction in Diameter.	4″	6″	8″	10″	12″	16″	20″	24″	30″	36″	48″	60″
		Value of *c* after Making Allowance for Decrease in Diameter.											
0	130	130	130	130	130	130	130	130	130	130	130	130	130
10	113	106	108	109	110	110	111	111	112	112	112	112	112
20	101	88	92	94	96	97	98	99	99	99	99	100	100
30	92	75	80	83	85	86	87	88	89	90	90	90	91
40	85	64	71	74	76	78	79	80	81	82	83	83	84
50	79.3	56	63	67	69	71	73	74	75	76	76	77	78
60	74.6	48	56	61	63	65	67	69	70	71	71	72	73
70	70.6	42	51	55	58	60	62	64	65	66	67	67	68
80	67.1	37	46	51	54	56	58	60	61	62	63	64	65
90	64.2	33	42	47	50	52	55	57	58	59	60	61	62
100	61.5	29	38	43	47	49	52	54	55	56	57	58	59

COMPARISON OF THE LOSS OF HEAD OF WATER IN PIPES OF VARIOUS AGES, AS COMPUTED BY THE METHODS USED

(1) by Coffin: "Graphical Solution of Hydraulic Problems."
(2) by Weston: "Friction of Water in Pipes."
(3) by Hazen & Williams: Figures used in this volume.

Age of Pipe in Years.	Diameter of Pipe in Inches.	Velocity of 1 Foot per Second.			Velocity of 3 Feet per Second.			Velocity of 5 Feet per Second.		
		Coffin.	Weston	Hazen & Williams.	Coffin.	Weston	Hazen & Williams.	Coffin.	Weston	Hazen & Williams.
New	4	1.55	1.18	1.32	11.7	10.4	10.2	30.0	29.0	26.0
"	16	0.28	0.25	0.26	2.09	2.20	2.00	5.3	6.2	5.2
"	48	0.067	0.080	0.072	0.51	0.71	0.55	1.3	2.0	1.4
10	4	1.88	1.54	1.90	16.0	13.6	15.0	44.0	38.0	38.0
"	16	0.34	0.33	0.35	2.9	2.9	2.7	7.8	8.1	7.0
"	48	0.08	0.10	0.10	0.7	0.9	0.7	1.9	2.6	1.9
20	4	2.30	1.90	2.70	21.0	17.0	21.0	61.0	47.0	53.0
"	16	0.41	0.41	0.44	3.8	3.6	3.4	11.0	10.0	9.0
"	48	0.10	0.13	0.12	0.9	1.2	0.9	2.6	3.2	2.3
40	4	3.10	2.60	4.90	31.0	23.0	38.0	96.0	65.0	96.0
"	16	0.55	0.56	0.65	5.6	5.0	5.0	17.0	14.0	13.0
"	48	0.13	0.18	0.17	1.4	1.6	1.3	4.2	4.4	3.3

SHORT METRIC EQUIVALENT PIPE TABLE.

Discharge in			Loss of Head in Meters per 1000 meters of length.								
Gallons Daily.	Cubic Meters Daily.		Diameters in Meters.								
c=100 Old.	c=100 Old.	c=130 New.	D=0.1 =3.94 Ins.	D=0.2 =7.87 Ins.	D=0.3 =11.81 Ins.	D=0.4 =15.75 Ins.	D=0.5 =19.68 Ins.	D=0.6 =23.62 Ins.	D=0.8 =31.50 Ins.	D=1.0 =39.37 Ins.	D=1.2 =47.24 Ins.
26,417	100	130	0.6	0.02							
39,626	150	195	1.2	0.04							
52,834	200	260	2.0	0.07	0.01						
66,042	250	325	3.1	0.11	0.01						
79,251	300	390	4.3	0.15	0.02						
92,459	350	455	5.8	0.20	0.03						
105,668	400	520	7.4	0.25	0.03	0.01					
132,085	500	650	11.2	0.38	0.05	0.01					
158,502	600	780	15.6	0.54	0.07	0.02	0.01				
211,336	800	1,040	26.6	0.91	0.13	0.03	0.01				
264,170	1,000	1,300	40.5	1.38	0.19	0.05	0.02	0.01			
317,004	1,200	1,560	57	1.93	0.27	0.07	0.02	0.01			
369,838	1,400	1,820	76	2.58	0.36	0.09	0.03	0.01			
422,672	1,600	2,080	97	3.30	0.46	0.11	0.04	0.02			
475,506	1,800	2,340	120	4.10	0.57	0.14	0.05	0.02			
528,340	2,000	2,600	146	5.0	0.69	0.17	0.06	0.02			
660,425	2,500	3,250	220	7.5	1.05	0.26	0.09	0.04			
792,510	3,000	3,900	310	10.6	1.47	0.36	0.12	0.05	0.01		
1,056,680	4,000	5,200	515	18.0	2.50	0.62	0.21	0.09	0.02	0.01	
1,320,850	5,000	6,500	800	27.2	3.80	0.93	0.31	0.13	0.03	0.01	
1,585,020	6,000	7,800	.....	38	5.3	1.31	0.44	0.18	0.04	0.02	0.01
2,113,360	8,000	10,400	.....	65	9.1	2.23	0.75	0.31	0.08	0.03	0.01
2,641,700	10,000	13,000	.....	99	13.7	3.38	1.13	0.47	0.12	0.04	0.02
3,170,040	12,000	15,600	.....	138	19.2	4.70	1.60	0.65	0.16	0.05	0.02
3,698,380	14,000	18,200	.....	183	25.6	6.3	2.10	0.87	0.22	0.07	0.03
4,226,720	16,000	20,800	.....	235	32.8	8.0	2.70	1.12	0.28	0.09	0.04
4,755,060	18,000	23,400	.....	292	41.8	10.0	3.40	1.38	0.34	0.12	0.05
5,283,400	20,000	26,000	.....	356	50	12.2	4.10	1.68	0.42	0.14	0.06
6,604,250	25,000	32,500	.....	......	75	18.4	6.2	2.55	0.63	0.21	0.09
7,925,100	30,000	39,000	.....	......	105	25.8	8.7	3.55	0.88	0.29	0.12
10,566,800	40,000	52,000	.....	......	180	43	14.8	6.1	1.50	0.50	0.21
13,208,500	50,000	65,000	.....	......	272	67	22.4	9.2	2.26	0.76	0.31
15,850,200	60,000	78,000	.....	......	......	93	31.5	12.8	3.20	1.07	0.44
21,133,600	80,000	104,000	.....	......	......	160	53	22.0	5.4	1.80	0.75
26,417,000	100,000	130 000	.....	......	......	240	81	33.0	8.2	2.73	1.13

VENTURI METERS.

TABLE SHOWING HEAD LOST IN EXCESS OF THAT LOST IN STRAIGHT PIPE, EXPRESSED IN TERMS OF THE VELOCITY HEAD IN THE PIPE.

Note.—The velocity head for any given discharge and pipe size may be found in the pipe tables.

Diameter of Throat, Inches.	Diameter of Pipe.														
	10″	12″	16″	20″	24″	30″	36″	42″	48″	54″	60″	66″	72″	78″	84″
	Loss of Head in Terms of Velocity Head.														
4	6	12	39												
4.5	4	7	20												
5	2	5	15	38											
5.5	....	3	10	25											
6	....	2	7	18	37										
6.5	....	....	5	13	26										
7	....	....	4	10	20										
7.5	....	....	3	7	15	36									
8	....	....	2	5	11	28									
8.5	....	....	....	4	9	22									
9	....	....	....	3	7	17	35								
9.5	....	....	....	3	6	14	28								
10	....	....	....	2	5	11	23								
11	....	....	....	....	3	7	15	29							
12	....	....	....	....	2	5	11	20	34						
13	....	....	....	....	....	4	8	15	25						
14	....	....	....	....	....	3	6	11	18	29					
15	....	....	....	....	....	2	4	8	14	22	34				
16	....	....	....	....	....	....	3	6	11	17	26				
17	....	....	....	....	....	....	3	5	8	13	20	29			
18	....	....	....	....	....	....	2	4	6	10	16	23	33		
19	....	....	....	....	....	....	....	3	5	8	13	18	26		
20	....	....	....	....	....	....	....	2	4	7	10	15	21	29	
21	....	....	....	....	....	....	....	2	3	6	8	12	18	24	32
22	....	....	....	....	....	....	....	....	3	5	7	10	14	20	27
23	....	....	....	....	....	....	....	....	2	4	6	8	12	16	22
24	....	....	....	....	....	....	....	....	2	3	5	7	10	14	19
25	....	....	....	....	....	....	....	....	....	3	4	6	9	12	16
26	....	....	....	....	....	....	....	....	....	2	4	5	7	10	14
27	....	....	....	....	....	....	....	....	....	2	3	4	6	9	12
28	....	....	....	....	....	....	....	....	....	....	3	4	5	7	10
29	....	....	....	....	....	....	....	....	....	....	2	3	5	6	9
30	....	....	....	....	....	....	....	....	....	....	2	3	4	6	8
31	....	....	....	....	....	....	....	....	....	....	....	3	4	5	7
32	....	....	....	....	....	....	....	....	....	....	....	2	3	4	6

UNDERDRAINS FOR SAND FILTERS.

(No compensating orifices used.)

Rate of filtration, million gallons per acre daily	3	4	5	6	8	10	15
Assumed resistance of clean sand, feet	0.090	0.120	0.150	0.180	0.240	0.300	0.450
Total allowable friction and velocity head in underdrainage system	0.022	0.030	0.037	0.045	0.060	0.075	0.112
Approximate ratio of filter area to area of main drain	6,300	5,600	5,100	4,700	4,200	3,800	3,200
Approximate velocity in main drain (varying somewhat with size)	0.67	0.80	0.90	1.00	1.18	1.34	1.68
Approximate velocity in laterals (varying somewhat with size)	0.40	0.48	0.55	0.61	0.72	0.82	1.04

MAXIMUM AREAS DRAINED IN SQUARE FEET.

2″ round lateral	79	70	64	59	53	48	41
3″ " "	180	160	147	137	122	111	93
4″ " "	325	288	264	245	218	200	168
5″ " "	517	460	420	390	345	316	266
6″ " "	750	670	610	570	500	460	390
8″ " "	1,340	1,200	1,090	1,010	900	820	690
6″ split "	360	320	290	270	240	220	180
8″ " "	640	570	520	490	430	400	320
10″ " "	1,020	900	830	770	680	630	530
12″ " "	1,480	1,320	1,200	1,120	1,000	910	770
10″ round main	3,400	3,000	2,700	2,500	2,200	2,000	1,700
12″ " "	4,900	4,300	3,900	3,600	3,200	2,900	2,400
15″ " "	7,700	6,900	6,200	5,800	5,100	4,600	3,900
18″ " "	11,200	10,000	9,000	8,300	7,400	6,700	5,600
21″ " "	15,300	13,600	12,300	11,400	10,000	9,100	7,600
24″ " "	20,000	17,700	16,100	14,900	13,200	12,000	10,000
27″ " "	25,400	22,400	20,300	18,800	16,600	15,100	12,600
30″ " "	31,500	27,800	25,300	23,400	20,700	18,800	15,700
33″ " "	38,000	34,000	31,000	28,000	25,000	23,000	19,000
36″ " "	45,000	40,000	37,000	34,000	30,000	27,000	22,000

Note.—For main drains, c is taken as 110, and it is assumed that the space drained is twice as long as wide. For lateral drains, c is taken as 100, and it is assumed that the space drained is four times as long as wide. Considerable change in shape of area drained does not greatly affect the results, and the figures may be used as approximations for all ordinary conditions.

THE FLOW OF WATER OVER WEIRS.

SHARP-EDGED WEIRS.

THE basis of our experimental knowledge of the discharge of water over weirs of size applicable to the cases usually encountered in practice rests primarily upon three investigations, viz.:

(*a*) That of Mr. Jas. B. Francis, M. Am. Soc. C. E., made at Lowell, Mass., in 1852.

(*b*) That of Messrs. Alphonse Fteley and Frederic P. Stearns, Members Am. Soc. C. E., made at Boston, Mass., in 1877, 1878, and 1879.

(*c*) That of M. Henry Bazin, Inspecteur General des Ponts et Chaussees, made at Dijon, France, in 1886, 1887, and 1888.

Each of these investigations has given rise to a formula for determining the flow of water over a sharp-edged vertical weir without end contractions, named from the observers, and these three formulas comprise those most commonly applied in practice.

The symbols used in these formulas and in the following tables are:

H = the total head or height from the crest of the weir to still water, measured in feet;

h = the observed head or height of the surface of the running water above the crest of the weir, at some convenient point, measured in feet;

h_v = the head to which the mean velocity of the approaching water is due, measured in feet—i.e., $h_v = \frac{v^2}{2g}$—where v = velocity in feet per second;

L = the total length of the crest of the weir, or the mean width of the over-falling sheet at the plane of the weir, measured in feet;

p = the height of the crest of the weir above the bottom of the channel of approach, measured in feet;

Q = the quantity of water discharged per second over a weir, measured in cubic feet;

g = the acceleration due to gravity = 32.16 feet per second.

The Francis formula, then, is:

$$Q=3.33LH^{3/2} \quad \text{or} \quad Q=3.33L[(h+h_v)^{3/2}-h_v^{3/2}].$$

The Fteley and Stearns formula is:

$$Q=3.31LH^{3/2}+0.007L \quad \text{or} \quad Q=3.31L(h+1.5h_v)^{3/2}+0.007L.$$

The Bazin formula is:

$$Q=mLh\sqrt{2gh}, \text{ where } m=\left(0.405+\frac{0.00984}{h}\right)\left[1+0.55\left(\frac{h}{p+h}\right)^2\right].$$

The several observers used different methods of reading the head h, and for an accurate application of the formulas the head should be read in the same manner as in the original experiments.

Mr. Francis, in the experiments upon which his formula is based, observed the head as communicated through a small orifice (about $\frac{1}{4}$ inch diameter) in the side of the channel of approach, about 1 foot below the level of the crest and 6 feet up-stream therefrom, which was connected through a pipe about 18 inches long to a cistern, where the surface was read by a hook gage. The weir was of $L=10$ feet.

In a part of their experiments, which were made on a weir with $L=5$ feet, Messrs. Fteley and Stearns made use of a small orifice in the center of a plank 10 inches long, set with its face vertical and parallel to the axis of the channel of approach, and about 16 inches from the side wall, so that the orifice was about 10 inches above the bottom and 6 feet up-stream from the weir, the orifice being connected by piping to a movable cistern, in which the head was read by a hook gage. For the rest of their experiments these observers made use of eight small orifices simultaneously, which were connected in pairs, opening in opposite directions. These orifices were in the center of steel plates about 6 inches long, located parallel to the current at about the level of the crest of the weir, and were 6 feet up-stream therefrom, and 18 inches and 7 feet respectively from the side walls of the channel, the weir being of $L=19$ feet.

In the experiments of M. Bazin, who worked on weirs of $L=6.56$ feet, 3.28 feet, and 1.64 feet, the head was communicated through an orifice 4 inches in diameter, at the bottom of the channel of approach and 16.3 feet up-stream from the weir, connecting with a pit, wherein the surface of water was located by a hook gage and a dial-float.

Experimental comparisons of these formulas, where the heads were observed in the manner described for each, has shown them to agree

within $2\frac{1}{2}$ per cent for heads from 0.5 up to 3 feet, and that the Fteley and Stearns and the Bazin formulas agree within 2 per cent for heads up to 4 feet. The Francis formula was only intended to apply between heads of 0.5 and 2.0 feet, and should not be used for higher heads. Where other methods of reading the head are used, errors of as much as 10 per cent may be introduced. One of the most erroneous of these is by the aid of a pipe placed in the current parallel to the weir and perforated upon its bottom or top.

A very convenient as well as accurate means of reading the head upon a weir, and one which introduces but a small error, is by the use of a sharp-pointed plumb-bob suspended upon a steel tape, the latter passing over a block on which a line is drawn at right angles to the tape, the reading taken being that of the tape where the line intersects it. The reading of the tape corresponding to the position of the bob when in contact with the water surface, when the latter is at the level of the crest of the weir, must be determined and used as the datum. The point of observation should be far enough away from the crest of the weir to be beyond the curve of the approaching sheet, and the elevation of the water surface may be read by allowing the point of the bob to come in contact with it, the bob being still, or by swinging the bob and allowing it to cut the water surface. Whichever method is adopted should be used in determining the datum reading, as the indications are somewhat different. Such readings will be found to fit the Bazin formula more accurately than they will either of the others.

To facilitate the use of this formula, the following table giving the discharge over weirs of various heights from 2 to 30 feet and for heads from 0.1 to 6.0 feet is presented. The discharges in this table can only be used in cases where the level of the water surface on the down-stream side of the weir is below the crest, and the space between the face of the weir and the over-falling sheet is in free connection with the outside air. If a partial vacuum be formed behind the sheet, from lack of free circulation, the discharge will be increased, under some conditions as much as 5 per cent. If the water on the down-stream side rise above the crest, the weir then becomes submerged or drowned and the discharge is consequently decreased.

DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet. Length of weir $=L$.

h in Feet.	p=2 Ft. Q Cu. Ft. per Sec.	p=3 Ft. Q Cu. Ft. per Sec.	p=4 Ft. Q Cu. Ft. per Sec.	p=5 Ft. Q Cu. Ft. per Sec.	p=6 Ft. Q Cu. Ft. per Sec.	p=7 Ft. Q Cu. Ft. per Sec.	p=8 Ft. Q Cu. Ft. per Sec.	h in Feet.
0.1	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.1
0.2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.2
0.3	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.3
0.4	0.88	0.88	0.88	0.87	0.87	0.87	0.87	0.4
0.5	1.23	1.22	1.21	1.21	1.21	1.21	1.21	0.5
0.6	1.62	1.59	1.59	1.58	1.58	1.58	1.58	0.6
0.7	2.04	2.01	1.99	1.98	1.98	1.98	1.98	0.7
0.8	2.50	2.45	2.43	2.42	2.41	2.41	2.41	0.8
0.9	3.00	2.93	2.90	2.88	2.88	2.87	2.86	0.9
1.0	3.53	3.44	3.40	3.38	3.36	3.36	3.35	1.0
1.2	4.68	4.55	4.48	4.47	4.42	4.41	4.40	1.2
1.4	5.99	5.78	5.68	5.62	5.58	5.56	5.54	1.4
1.5	6.65	6.44	6.30	6.23	6.20	6.18	6.16	1.5
1.6	7.40	7.12	6.97	6.89	6.84	6.80	6.78	1.6
1.8	8.93	8.56	8.37	8.25	8.18	8.13	8.09	1.8
2.0	10.58	10.12	9.87	9.72	9.62	9.55	9.51	2.0
2.2	12.34	11.77	11.46	11.27	11.14	11.06	10.99	2.2
2.4	14.20	13.53	13.15	12.91	12.75	12.64	12.56	2.4
2.5	15.20	14.43	14.09	13.80	13.61	13.50	13.42	2.5
2.6	16.16	15.38	14.92	14.63	14.44	14.30	14.20	2.6
2.8	18.23	17.32	16.79	16.44	16.21	16.04	15.92	2.8
3.0	20.39	19.36	18.74	18.33	18.06	17.86	17.71	3.0
3.2	22.64	21.48	20.77	20.31	19.98	19.75	19.58	3.2
3.4	24.98	23.70	22.89	22.36	21.99	21.72	21.52	3.4
3.5	26.20	24.83	24.00	23.43	23.01	22.73	22.48	3.5
3.6	27.41	25.99	25.09	24.49	24.06	23.75	23.52	3.6
3.8	29.94	28.38	27.38	26.70	26.22	25.87	25.60	3.8
4.0	32.54	30.84	29.74	28.99	28.45	28.05	27.74	4.0
4.2	35.22	33.39	32.18	31.35	30.75	30.30	29.96	4.2
4.4	37.99	36.01	34.70	33.78	33.12	32.62	32.24	4.4
4.6	40.83	38.71	37.29	36.29	35.56	35.01	34.58	4.6
4.8	43.75	41.49	39.96	38.87	38.07	37.46	37.00	4.8
5.0	46.71	44.31	42.67	41.49	40.62	39.96	39.44	5.0
5.2	49.81	47.27	45.50	44.23	43.29	42.57	42.01	5.2
5.4	52.94	50.23	48.38	47.02	46.00	45.22	44.60	5.4
5.6	56.15	53.33	51.34	49.88	48.79	47.94	47.28	5.6
5.8	59.42	56.45	54.34	52.79	51.62	50.71	49.99	5.8
6.0	62.77	59.65	57.43	55.78	54.53	53.55	52.78	6.0

DISCHARGE PER FOOT OF LENGTH OVER SHARP-EDGED VERTICAL WEIRS, WITHOUT END CONTRACTIONS.

COMPUTED BY BAZIN'S FORMULA.

$$Q=\left(0.405+\frac{.00984}{h}\right)\left[1+0.55\frac{h^2}{(p+h)^2}\right]Lh\sqrt{2gh}.$$

Observed head $=h$. Height of weir $=p$. Discharge $=Q$. $g=32.17$ feet.
Length of weir $=L$.

h in Feet.	$p=9$ Ft. Q Cu. Ft. per Sec.	$p=10$ Ft. Q Cu. Ft. per Sec.	$p=12$ Ft. Q Cu. Ft. per Sec.	$p=16$ Ft. Q Cu. Ft. per Sec.	$p=20$ Ft. Q Cu. Ft. per Sec.	$p=25$ Ft. Q Cu. Ft. per Sec.	$p=30$ Ft. Q Cu. Ft. per Sec.	h in Feet.
0.1	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.1
0.2	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.2
0.3	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.3
0.4	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.4
0.5	1.21	1.21	1.21	1.21	1.20	1.20	1.20	0.5
0.6	1.57	1.57	1.57	1.57	1.57	1.57	1.57	0.6
0.7	1.97	1.97	1.97	1.97	1.97	1.97	1.97	0.7
0.8	2.40	2.40	2.40	2.40	2.40	2.40	2.40	0.8
0.9	2.86	2.86	2.86	2.85	2.85	2.85	2.85	0.9
1.0	3.35	3.34	3.34	3.33	3.33	3.33	3.33	1.0
1.2	4.39	4.38	4.38	4.37	4.36	4.36	4.36	1.2
1.4	5.53	5.52	5.51	5.49	5.49	5.48	5.48	1.4
1.5	6.14	6.13	6.12	6.11	6.10	6.09	6.09	1.5
1.6	6.76	6.74	6.73	6.71	6.69	6.69	6.68	1.6
1.8	8.07	8.05	8.02	7.99	7.98	7.97	7.96	1.8
2.0	9.47	9.44	9.40	9.36	9.34	9.33	9.32	2.0
2.2	10.95	10.91	10.86	10.81	10.78	10.76	10.75	2.2
2.4	12.50	12.45	12.39	12.32	12.28	12.25	12.24	2.4
2.5	13.36	13.28	13.19	13.14	13.10	13.07	13.05	2.5
2.6	14.13	14.07	13.99	13.90	13.85	13.82	13.80	2.6
2.8	15.83	15.76	15.66	15.54	15.48	15.44	15.42	2.8
3.0	17.60	17.52	17.39	17.25	17.18	17.13	17.10	3.0
3.2	19.45	19.34	19.19	19.02	18.93	18.87	18.83	3.2
3.4	21.36	21.24	21.06	20.86	20.75	20.68	20.63	3.4
3.5	22.38	22.22	22.00	21.83	21.71	21.62	21.60	3.5
3.6	23.34	23.20	22.99	22.75	22.62	22.53	22.48	3.6
3.8	25.39	25.23	24.99	24.71	24.56	24.45	24.39	3.8
4.0	27.51	27.32	27.05	26.72	26.55	26.42	26.35	4.0
4.2	29.69	29.48	29.17	28.79	28.59	28.45	28.36	4.2
4.4	31.94	31.70	31.34	30.92	30.66	30.52	30.42	4.4
4.6	34.25	33.98	33.58	33.10	32.84	32.65	32.53	4.6
4.8	36.62	36.33	35.88	35.35	35.05	34.83	34.70	4.8
5.0	39.03	38.70	38.21	37.61	37.28	37.03	36.88	5.0
5.2	41.56	41.20	40.65	39.98	39.61	39.33	39.17	5.2
5.4	44.11	43.71	43.12	42.38	41.96	41.66	41.47	5.4
5.6	46.74	46.31	45.65	44.84	44.38	44.04	43.83	5.6
5.8	49.41	48.94	48.22	47.33	46.83	46.45	46.22	5.8
6.0	52.15	51.64	50.86	49.90	49.34	48.92	48.67	6.0

LOW HEADS.

For heads below 0.2 foot the Bazin Formula gives discharges somewhat in excess of the experimental results of Fteley and Stearns, and in practice accurate weir measurement at low heads becomes extremely difficult on account of the increased relative importance of errors of observation, and of changes in the character of the flow if the edge of the weir has a measurable thickness. It may also be expected that the temperature of the water will exercise considerable influence. For these low heads the formula deduced by Fteley and Stearns for their small weir, $Q=3.33LH^{3/2}+0.0065L$, gives results varying from the experiments by from 4 to 6 per cent for heads from 0.2 to 0.07 foot, the lowest observed. The actual results were usually greater than those given by the formula. For a head of 0.1 foot this formula gives a discharge of 0.11 cu. ft. per second, as compared with 0.13 cu. ft. by Bazin. A value of 0.115 cu. ft. seems quite nearly correct for this head.

END CONTRACTIONS.

For weirs having end contractions the formula of Mr. Francis, modified as he proposed by subtracting the quantity $0.1nH$ from the value of L, making the formula $Q=3.33(L-0.1nH)H^{3/2}$, is the one generally recognized. In this modification n is the number of end contractions, or the proportion of a complete contraction. Recent experiments indicate that the effect of end contractions is not to be provided for by so simple a formula, and until more data are available such weirs should be avoided so far as circumstances will permit.

VERY HIGH WEIRS.

When the weir is of such dimensions in proportion to the channel of approach that the velocity of the approaching water may become zero, the formula of Bazin reduces to $Q=\left(0.405+\frac{0.00984}{h}\right)Lh\sqrt{2gh}$, which corresponds to $p=$infinity, and the following table gives the value of the several factors, and the discharge under this condition for $L=1$ foot. In this and the preceding table g has been taken as 32.173 feet, that being its value for latitude 40° and an elevation above sea-level of 500 feet.

VALUES OF FACTORS IN BAZIN'S FORMULA AND DISCHARGE OVER WEIR OF INFINITE HEIGHT.

Head = h in Feet.	$\sqrt{2gh}$	$h\sqrt{2gh}$	$\left(0.405+\frac{0.00984}{h}\right)$	Discharge Q in Cu. Ft. per Sec. for $L=1$ Foot.
0.1	2.537	0.254	0.503	0.13
0.2	3.587	0.717	0.454	0.33
0.3	4.394	1.318	0.438	0.58
0.4	5.073	2.029	0.430	0.87
0.5	5.672	2.836	0.425	1.20
0.6	6.213	3.728	0.421	1.57
0.7	6.711	4.698	0.419	1.97
0.8	7.175	5.740	0.417	2.40
0.9	7.610	6.849	0.416	2.85
1.0	8.021	8.021	0.415	3.33
1.2	8.787	10.544	0.413	4.36
1.4	9.491	13.287	0.412	5.48
1.5	9.824	14.736	0.412	6.07
1.6	10.147	16.234	0.411	6.68
1.8	10.762	19.361	0.410	7.95
2.0	11.344	22.688	0.410	9.30
2.2	11.898	26.178	0.409	10.72
2.4	12.427	29.825	0.409	12.20
2.5	12.683	31.707	0.409	12.97
2.6	12.934	33.631	0.409	13.75
2.8	13.423	37.585	0.409	15.35
3.0	13.894	41.682	0.408	17.02
3.2	14.349	45.915	0.408	18.74
3.4	14.791	50.290	0.408	20.51
3.5	15.008	52.523	0.408	21.42
3.6	15.219	54.785	0.408	22.34
3.8	15.637	59.420	0.408	24.22
4.0	16.043	64.170	0.407	26.15
4.2	16.439	69.045	0.407	28.13
4.4	16.826	74.030	0.407	30.15
4.6	17.204	79.140	0.407	32.22
4.8	17.574	84.360	0.407	34.34
5.0	17.936	89.625	0.407	36.48
5.2	18.292	95.120	0.407	38.70
5.4	18.640	100.656	0.407	40.95
5.6	18.983	106.305	0.407	43.24
5.8	19.318	112.044	0.407	45.56
6.0	19.648	117.888	0.407	47.94

FLAT-CREST AND OTHER WEIRS.

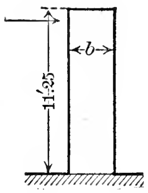
The formulas for the discharge of vertical sharp-edged weirs cease to be applicable when the crest is widened or the up-stream face inclined, and in order to determine what modifications should be made in the computed results, experiments have been made upon some twenty-five models of different forms, with $L=16$ feet and p as great as 11.25 feet, using heads up to and in some cases a little above 4 feet.

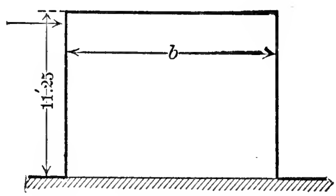
From these experiments the factors by which to multiply the computed discharge for a sharp-edged weir of the same L and p, to give the actual discharge over each form of crest, have been deduced for the heads given in the following tables, wherein the first column gives the head and the columns headed II the multipliers. To use the tables, the discharge for the weir of given form should be first computed as for a vertical sharp-edged weir of the same height and length, using any of the above formulas, or the tables on pages 66, 67, and 69, and the resulting Qs should then be multiplied by the factor in the proper column under II, when the accuracy of the result may be expected to correspond to that of the first computation. So long as the top of the weir is flat and the up-stream face vertical, it appears that the factors given should be applicable to any height of weir, but if the up-stream face or any part of the profile up-stream, from the highest point of the weir, is inclined, the factor will change with the height of the weir, as is shown by the table for triangular weirs.

On all the models having vertical down-stream faces, including model P, air was admitted to the space underneath the sheet. On models D and E experiments were made with the space underneath the sheet unaerated, so that a partial vacuum existed there, which is shown to increase the discharge about 5 per cent at the high heads. For the weirs with inclined down-stream faces, models F to O inclusive, no air was admitted under the sheet. A comparison of the results upon models G and H shows the effect of rounding the up-stream corner of this weir to be an increase in discharge of about 4 per cent at the high heads.

WEIR DISCHARGE.

RECTANGULAR FLAT-TOPPED WEIRS.





I. Head in Feet, *h*.	II Multipliers of Discharge over Sharp-edged Vertical Weir of Same *L* and *p*.							
	$b=$ 0.48 Ft.	$b=$ 0.93 Ft.	$b=$ 1.65 Ft.	$b=$ 3.17 Ft.	$b=$ 5.84 Ft.	$b=$ 8.98 Ft.	$b=$ 12.24 Ft.	$b=$ 16.30 Ft.
0.5	0.902	0.830	0.819	0.797	0.785	0.783	0.783	0.783
1.0	0.972	0.904	0.879	0.812	0.800	0.798	0.795	0.792
1.5	1.000	0.957	0.910	0.821	0.807	0.803	0.802	0.797
2.0	1.000	0.989	0.925	0.821	0.805	0.800	0.798	0.795
2.5	1.000	1.000	0.932	0.816	0.800	0.795	0.792	0.789
3.0	1.000	1.000	0.938	0.813	0.796	0.791	0.787	0.784
3.5	1.000	1.000	0.942	0.810	0.793	0.787	0.783	0.780
4.0	1.000	1.000	0.947	0.808	0.790	0.783	0.780	0.777

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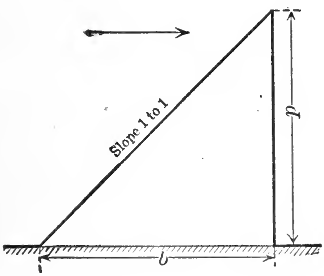
WEIR DISCHARGE.

TRIANGULAR WEIRS.



I. Head in Feet, h.	II. Mulitpliers.	
	$b=p=$ 6.65 Ft.	$b=p=$ 11.25 Ft.
0.5	1.060	1.060
1.0	1.079	1.079
1.5	1.091	1.092
2.0	1.086	1.097
2.5	1.076	1.096
3.0	1.067	1.095
3.5	1.060	1.094
4.0	1.054	1.093

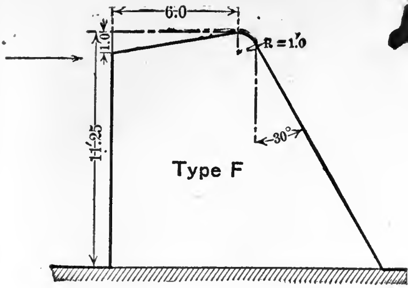
COMPOUND WEIRS.

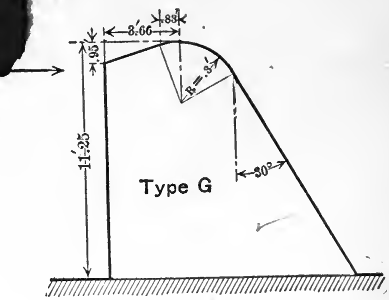
See opposite page.

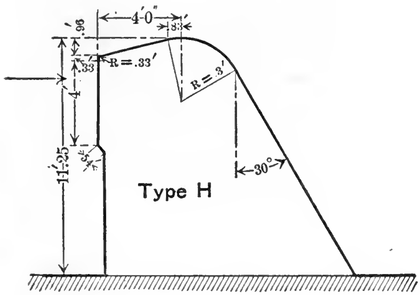
I. Head in Feet, h.	II. Multipliers.						
	Type F.	Type G.	Type H.	Type I.	Type J.	Type K.	Type L.
0.5	0.964	0.932	0.934	0.968	0.971	0.971	0.971
1.0	1.026	0.982	1.000	1.008	1.040	1.040	0.983
1.5	1.064	1.015	1.040	1.032	1.083	1.092	1.012
2.0	1.066	1.031	1.061	1.041	1.105	1.126	1.040
2.5	1.025	1.038	1.073	1.043	1.118	1.146	1.057
3.0	0.992	1.044	1.082	1.044	1.128	1.163	1.072
3.5	0.966	1.049	1.090	1.045	1.136	1.177	1.085
4.0	0.944	1.053	1.097	1.046	1.144	1.190	1.097

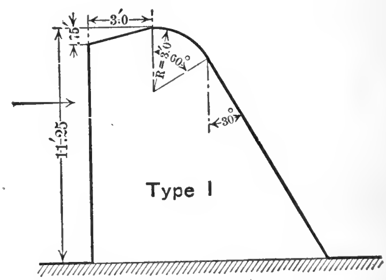
WEIR DISCHARGE.

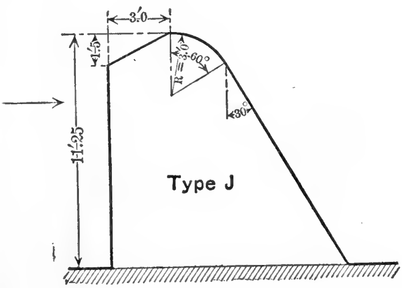
COMPOUND WEIRS.

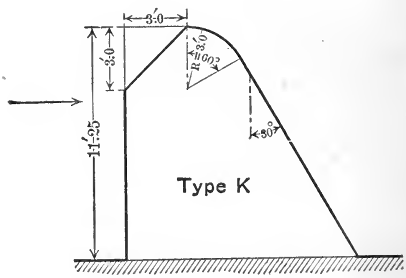


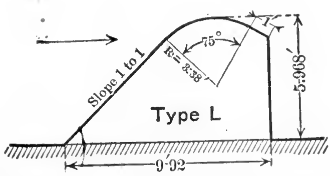












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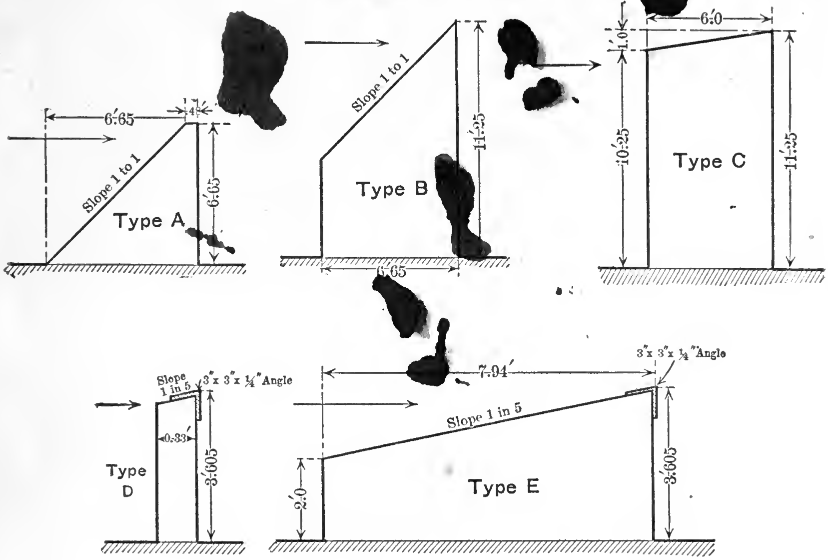
WEIR DISCHARGE.

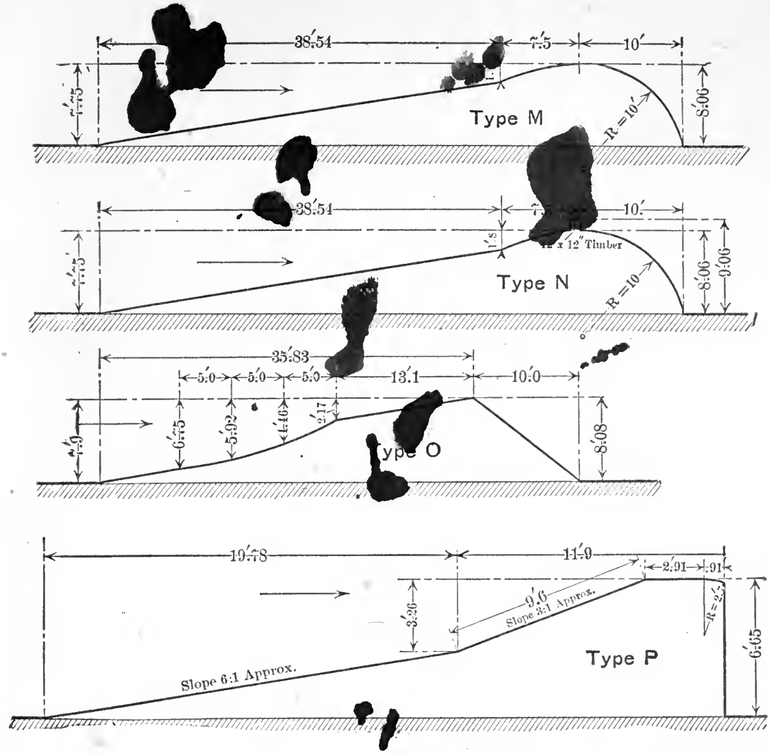
TRAPEZOIDAL WEIRS.



I. Head in Feet, *h*.	II. Multipliers of Discharge over Sharp-edged Vertical Weir of Same *L* and *p*.						
	Type A.	Type B.	Type C.	Type D.	D with Vacuum.	Type E.	E with Vacuum.
0.5	0.968	1.060	1.043	1.069	1.088	1.069	1.069
1.0	1.071	1.079	1.040	1.079	1.106	1.079	1.079
1.5	1.077	1.091	1.037	1.084	1.117	1.088	1.092
2.0	1.081	1.096	1.027	1.057	1.092	1.063	1.083
2.5	1.077	1.093	1.015	1.041	1.079	1.049	1.081
3.0	1.074	1.090	1.005	1.028	1.068	1.039	1.080
3.5	1.071	1.087	0.996	1.018	1.059	1.029	1.079
4.0	1.069	1.085	0.989	1.009	1.051	1.021	1.078

WEIR DISCHARGE.

COMPLEX WEIRS.



I. Head in Feet, *h*.	II. Multipliers.			
	Type M.	Type N.	Type O.	Type P.
0.5	0.964	0.897	1.095	0.920
1.0	0.965	0.946	1.088	0.915
1.5	0.963	0.999	1.084	0.914
2.0	0.949	1.025	1.069	0.935
2.5	0.933	1.039	1.051	0.950
3.0	0.920	1.052	1.035	0.962
3.5	0.911	1.063	1.024	0.972
4.0	0.903	1.072	1.014	0.982

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